AN EMPIRICAL APPROACH TO THE EVALUATION OF FACTORS IN LOCAL AUTHORITY HOUSING MAINTENANCE REQUIREMENTS IN THE CITY OF MANCHESTER

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For a study over a long period as this, to prepare a shortlist of those to whom gratitude should be extended is almost as difficult as the study itself. For such a task as this, oversight and limitation find meaning and expression. However, life itself is about recognising one's limitation and being prepared to own up to it when occasions demand. I therefore appreciate that I may not be able to acknowledge all worthies in this page, but rest in the confidence that such worthies would understand and bear with my limitation in this regard.

My thanks go to my supervisor, Trevor Mole without whose support and patience my ambition of completing this study would have remained a perpetual mirage. Of him, I could say, 'seest thou a man diligent in his ways, he shall stand before kings and not before mere men'. I shall not fail to acknowledge the man who held me by the hand when as yet my sight in this field was dim and fuzzy, Vernon Marston. I owe so much to his fervour, support and concern during the early stages of this study.

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Through it all, I owe my life and my all to God who has never withheld from me those things and gifts that I needed most at every stage in life's journey.

DEDICATION

This thesis is dedicated to:

My wife, Olukemi;

My daughters, MoyinOluwa and FiyinfOluwa;

My father and mother, Folayan and Olawamide;

My uncle, Olayinka Olubodun; and

My mother-in-law, Abike Fadeyi.

ABSTRACT

The thesis is concerned with the evaluation of factors in Local Authority housing maintenance requirements in the City of Manchester.

Since 1982, expenditure in housing maintenance and repair works has consistently accounted for more than 50% of total expenditure on maintenance and repair work. In turn, maintenance and repair work accounts for almost 50% of total construction output in the UK. Given this level of sectorial contribution, it is apt to understand the factors which affect defects in dwelling buildings and hence maintenance requirements. This thesis reviews the catalogue of building defect causative factors leading to the conclusion that social and tenants' characteristics are equally important.

The study is based, chiefly, on a postal questionnaire survey of building surveyors involved in day-to-day identification of defects as well as tenants of the sampled dwellings; and computer cost records of maintenance on dwellings within the sample. A total of 45 completed questionnaires from building surveyors, and 252 Council tenants with corresponding computer cost records formed the data base for the analyses conducted.

The building surveyors' questionnaire assisted in the identification of defect-cause criteria which relate to the internal attribute of the dwelling building. The consistency of the resulting data was confirmed by the use of Kendall Coefficient of Concordance. An analysis is described of the manipulated data set using regression analysis. The analysis found that Changing standard contributes (38%) of (building structure related factors') impact on maintenance requirement variance, construction factors (23%), design factors (22%), vandalism (12%) and age factors (6%). The intercorrelations among these five defect-cause criteria within the building object necessitated further analysis using the principal component analysis. This resulted in the extraction of nine significant factors showing how the initial five factors combine to exert their influence on the building. In all, this family of building structure related factors contribute 32% of the variation in maintenance requirements.

Combining the data from the tenants' questionnaire, computer cost information and dwelling survey, regression model testing was employed to identify the significant factors. This was facilitated with the use of three indices of housing maintenance requirements as the dependent variables, namely; reactive maintenance cost, property condition and satisfaction among tenants. Nine factors (six of which relate to tenant's characteristics) pertaining to tenant, environmental and housing management were significantly influential.

CHAPTER ONE
INTRODUCTION

1.1 Introduction to the subject matter

The research was begun partly in response to earlier research efforts which generally dealt with an examination of maintenance factors in isolation, most of which often formulated maintenance action and priority out of context with factors bearing upon those needs, and chiefly from the author's work experience as a principal surveyor responsible for both programmed and day-to-day maintenance works on council housing stock - consisting of about 9,000 mixed dwelling types.

Whilst earlier research efforts have formulated techniques for prioritising works, these techniques can be described as generally prognostic, with a penchant to confirming the stockholder's original ideas on how maintenance action should be pursued. In practice, this approach may be justified in the light of funding restrictions and political consideration. The position at the moment between the client and the building surveyor is almost akin to patient-GP relationship, where the patient tells the GP his ailment, and also informs him of his efforts at self-medications in the hope that the GP will find an optimum prescription for his ailment around his self-medication. In contrast to this analogy, the study strives to find a solution with or without existing self-medication indulgences of the patient. To this end, the study can be described as being truly diagnostic in relation to what components should take priority.

The depleting earth resources resulting from gross exploitation and growing global population make a clarion call for the need to evolve a means of effectively conserving these resources. This view was echoed when Jonge (1990) argued that past decades have witnessed strong emphasis on the design and construction of new building and called for a shift in emphasis as available physical and financial resources are almost being over-stretched. This observation was a reverberation of Bromilow and Pawsey's (1987) that property owners were more interested with the provision of new buildings than they were with the costs of maintaining and operating their buildings.

A radical shift in emphasis of this nature requires the development of methods and instruments to manage existing portfolios of building assets. This need is all the more urgent in the face of developing trends in nations' strict economic measures to conserve scarce fund (Dixon, 1990), thereby making less and less fund available for new developments.

It would appear that the way out is to seek to conserve available assets by prolonging their lives, consistent with economy, in order to meet the ever growing human need for controlled environment and space. In appreciation of this dire need, more thorough attention to and examination of existing buildings has been gaining a high momentum (Kondo *et al*, 1990). In their view, this is not purely because of increased safety consciousness, but in order to gain a comprehensive understanding of building deterioration and to develop effective methods of building maintenance and efficient repair in suitable time.

An analogy between the human physiology and a building can be aptly drawn. Like the human body, a building is a complex integration of different components, with each meeting a definite function, and all working together in such a manner as to forestall any likely impairment to the primary need of the specific building all through its life time. This is the very essence of any maintenance action - its efficiency is in being able to sustain the building in this condition at all times for the benefit of the user. In order to achieve this objective, it is important to be able to relate each component of the building to one another from the perspective of durability and life expectancy, and the larger environment.

The paradox of the building structure is that those features of the building which appear cosmetic in nature, are at the centre of its performance, the failure of which will cause the building to significantly under perform. In fact, the most frequent maintenance items in housing are not necessarily the anatomical frame of the building.

The earlier the construction industry began to realise and to actualise that property investment is developing and maintaining assets, and not just constructing and designing, the more the existing scarce funds will be conserved (Pollock, 1990), as the construction of a building is merely the less significant beginning, in cost terms, of an expensive life time (Bird 1987).

In a study of cost effectiveness of design decisions, White (1969) reported that running costs of an office block will exceed capital costs in less than nine years of occupation. Notwithstanding this stark finding, Harrison (1990) has noted the dismal backward attitudes to maintenance in all sectors of the construction industry. This according to him is evidenced in the attitudes of architects and quantity surveyors who always presume that the cost-in-use of the building is necessarily inversely related to the initial building cost.

1.2 Economic importance and growth of maintenance

UK's expenditure on maintenance, repair and refurbishment now accounts for almost half the turnover of the construction industry at current prices. In 1995 alone, work on existing construction as repair maintenance accounted for £25.9 billion (as shown in Table 1.1).

The quinquennial English House Condition Surveys reveal that spending on private housing is often difficult to monitor to say the least. However, it is generally believed that this may not be a serious shortcoming because this is an area which is relatively insensitive to improvement by research and development. This view stands to reason because of extensive individual variability involved and there is a difficulty in persuading individuals to accept research findings unless such findings are adopted by the government as policies.

Figure 1.1 shows a comparative sectorial investment between new work, and repair and maintenance work at 1990 prices during the period 1970-1995. The share of repair and maintenance work increased steadily from 28% in 1970 to 45% in 1980. Between 1980 and 1990, there has been a general leverage in maintenance sector investment, with slight depressions in 1982 and 1987. This period coincided with the periods when the effects of the Right-To-Buy Act of 1980 began to be felt in public housing.

Table 1. 1: Expenditure on new work and repair and maintenance (all construction excluding infrastructure)

Year	New work	Repair and Maintenance	Total
1970	30, 999	12,450	43,449
1971	31,643	12,546	44,190
1972	31,398	13,758	45,155
1973	31,259	14,409	45,667
1974	26,550	14,037	40,587
1975	25,338	12,816	38,155
1976	25,626	12,068	37,694
1977	24,928	12,482	37,409
1978	25,861	14,415	40,276
1979	24,106	16,559	40,665
1980	21,172	17,378	38,550
1981	18,994	15,826	34,820
1982	20,069	15,990	36,060
1983[1]	13,634	11,877	25,511
1984[1]	14,538	13,328	27,776
1985[1]	15,305	14,358	29,663
1986[1]	16,683	15,366	32,049
1987[1]	19,903	17,625	37,528
1988[1]	24,763	20,090	44,853
1989[1]	29,320	22,830	52,150
1990[1]	30,762	24,544	55,307
1991[1]	27,726	23,389	51,115
1992[1]	24,814	22,658	47,472
1993[1]	23,556	22,767	46,323
1994[1]	25,086	24,353	49,439
1995[1]	26,627	25,900	52,527

Year[1]: 1983 to 1995 figures are at current prices, while 1970 to 1982 figures are at 1990 prices.

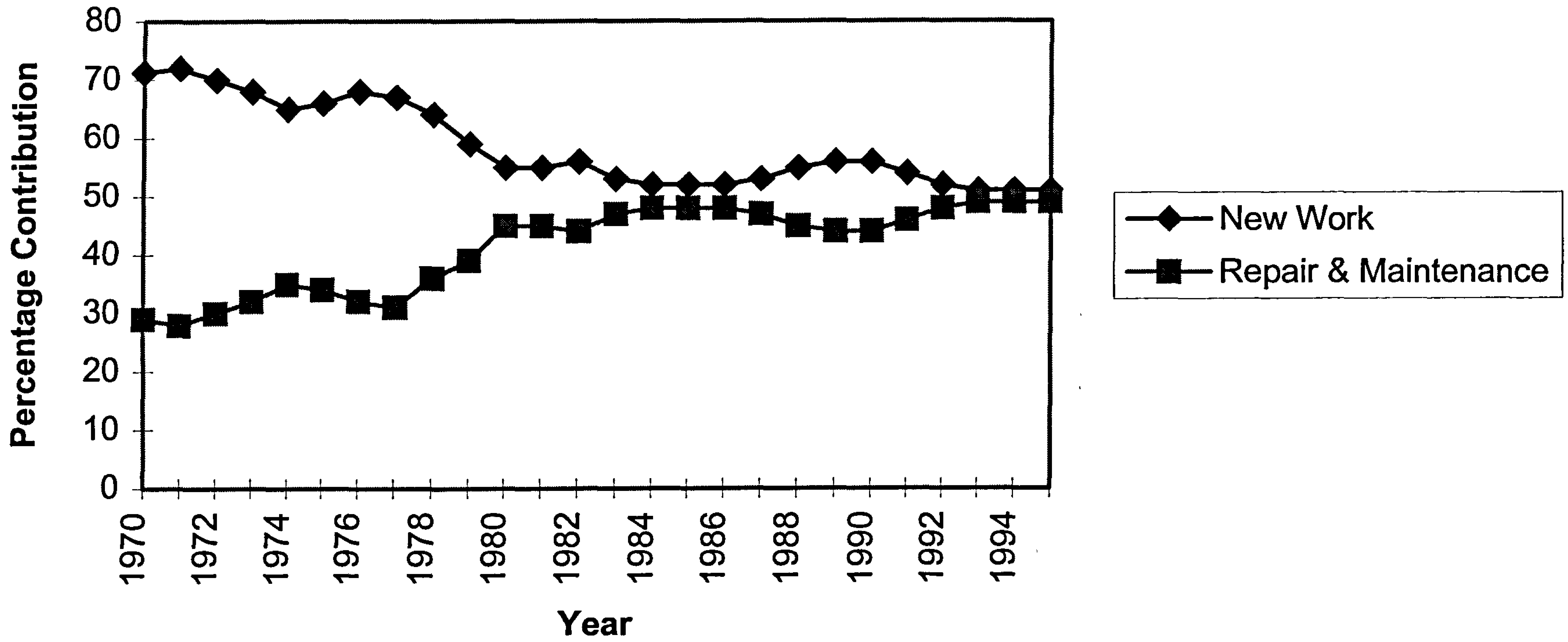


Figure 1.1: Comparative sectorial investment between new work, and repair and maintenance work by percentage (all construction excluding infrastructure)

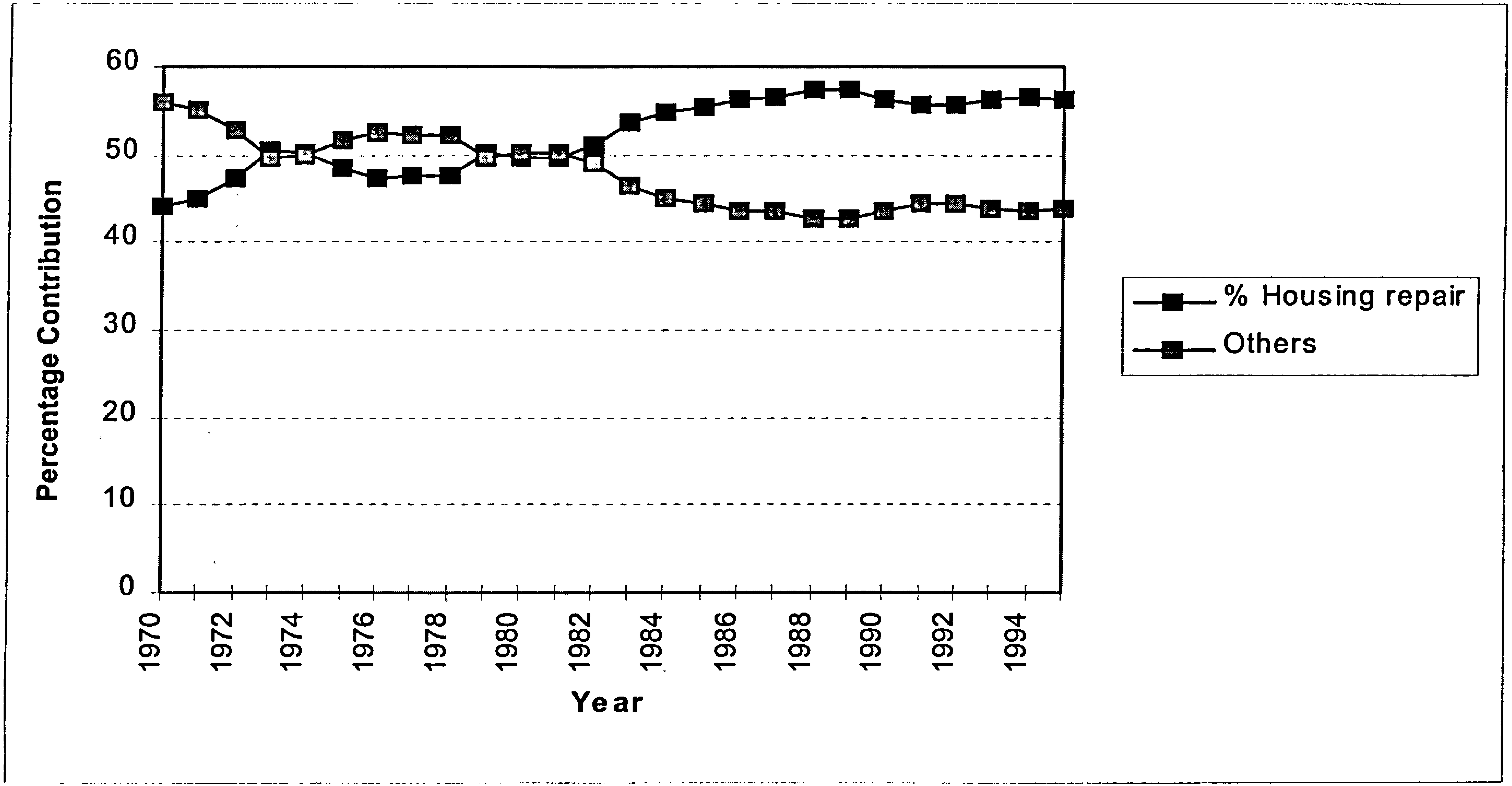


Figure 1.2: Relative sectorial investment in repair and maintenance work in percentage

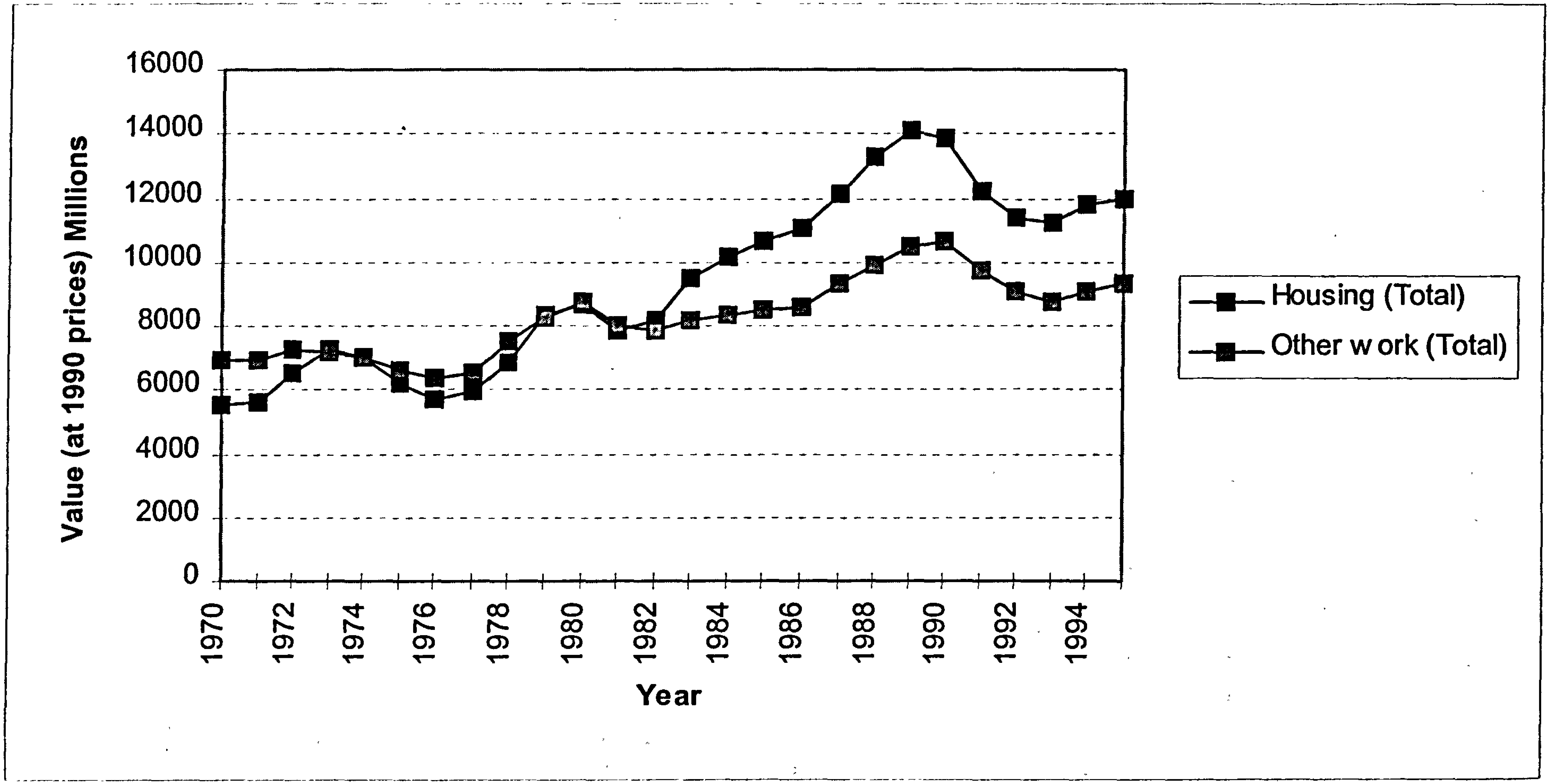


Figure 1.3: Relative sectorial investment in repair and maintenance work (at 1990 prices)

The transfer of house ownership to private individuals meant a reduction in maintenance expenditure by local authorities, which is not fully off-set by corresponding maintenance spending by individuals who took advantage of the Act. From 1990, the sector suffered a consistent fall in proportional contribution until 1993 when it began to pick up again. This corresponded with the peak of the recession, and therefore least expected, as investments in new construction tend to be more affected and thus potentially increasing the contribution of maintenance work. The contradiction in maintenance trend during this period of recession can be explained as the result of reduced public spending. This meant less and less fund is available to local authorities for housing maintenance work among others. This position is corroborated by the slight depression in housing maintenance investment between 1989 and 1992 as shown in Figure 1.2.

Figure 1.2 shows the shares of activity type in the total yearly repair and maintenance investment during the period 1970 - 1995. Figure 1.2 shows that except for the period between 1975 and 1979, maintenance investment in housing compared to other types of maintenance investment has consistently benefited from modest proportional increase. In quantitative terms, housing maintenance expenditure has outgrown other maintenance expenditure since 1981. What appears to be a modest fall in proportional contribution between 1989 and 1992 was because of simultaneous fall in maintenance across the two sectors (i.e. housing and other works).

Maintenance and repair activities were estimated in 1987 at almost 40% of the total construction turnover in Western Europe (Dandri, 1990). This share was exceeded in several countries like Western Germany, the UK, Italy and Netherlands.

Between 1980 and 1985 new house building declined in the European Union (EU) by a bold 30%. Subsequently, it recovered by 10% up until 1990. Between 1990 and 1995, because of economic decline world wide except for Japan and West Germany, the decline in new house building has even worsened.

As would be expected, maintenance activity has recorded correspondingly better performance. It only declined for one year between 1980 and 1981 by a sharp 10%. It took five years to recover the activity levels of 1980 in 1986. The following year, 1987, recorded an unprecedented boom, with activity increase of more than 15% (Gandri, 1990). Considering this monitoring of maintenance activities over the years, he predicted an activity increase of almost 30% above the 1980 level by 1990. Nireki *et al* (1990) predicted that there would possibly be a 'repair boom' in the 1990s as a necessary follow-up to the 'building boom' of the 1945 to 1970s.

There are several reasons behind this trend towards an increase in maintenance activity, some of which are financial, environmental, political and social. It can therefore be reasoned that as some of these factors become weaker, this trend may be reversed thus resulting in periodic trough and peak movements. It is however pertinent to emphasise that as the buildings being maintained have evolved through the various stages of development to a stage where they are a complex network of facilities fulfilling many of the primary and basic needs of modern man, it follows that the observed and predicted trend will probably continue. It cannot therefore be thought to be a short-term occurrence because any reversal will have dire consequence on the economy, the environment and society as a whole.

In a study of construction needs in the next decade carried out in 1989 in the Federal Republic of Germany, the needs were divided between maintenance of existing facilities and new construction. The results of the study revealed that total construction needs of Western Germany in the next decade are made up of 52% maintenance and 48% of new construction, whereas in 1987 maintenance activity accounted for less than 42%.

1.3 Statement of the problem

Building maintenance is said to be largely dependent upon a number of factors. Some of these factors are predetermined at the design stage, whilst others are determined during the life cycle period of the building (McGeorge and Betts, 1990). According to Chambers (1985) control of disrepair and stress in housing greatly depends on understanding the mechanism causing building decline.

A feasibility study sponsored by the R.I.C.S. in 1969, whose principal objective was the development of a reciprocal service for the collection and exchange of maintenance cost data (Pullen, 1987), led to the establishment of the Building Maintenance Cost Information Service. The terms of reference of the study was the formation of a data bank to furnish information which could help in the deployment of resources in maintenance, and the problem of defining the scope of building maintenance costs. This was a significant milestone in the evolution of an organised maintenance data base. Prior to this time, there had been several studies on various aspects of building maintenance (BRE, 1972; BRS, 1968; and BRS, 1963). Surprisingly, they all focused on the pattern of raw data collected from surveys rather than the factors governing the behaviour of the reported pattern. In drawing upon these studies, the BRE (1972) attempted to bring meaning into the data collected to assist comparison and went a step further to establish a trend between maintenance cost and the age of dwellings. The 'age' factor has since then been a common theme that runs through most, if not all of subsequent studies in the field. Among the most important findings by the BRE were existence of wide variations in maintenance expenditures resulting from the interplay of factors other than physical characteristics of the buildings studied. No more was however done by way of deciphering what these factors are or even could be.

Wyatt (1980) provided some insight into the complex phenomenon of maintenance costs when he posited that it is not sufficient to set maintenance standard requirements as a function of age of a dwelling. He contended that there are several other influencing factors which are essentially social, environmental, usage, economic, physical characteristics and even design.

In her study of public sector housing stock, Diacon (1991) identified the major cause of concern in British housing as the poor quality and continuing deterioration of the physical structure of residential dwellings. In reviewing her book, Malpass (1991) underscored the fact that the real cause for concern is the set of underlying factors which are responsible for disrepair and deterioration in the stock.

Holmes (1985) sought to consolidate upon these findings when in his work he analysed maintenance expenditure components. He evolved deductive explanations in order to identify various factors in maintenance. His data appeared as cost per dwelling without any standard reference point to dwelling size or any other design parameters. His study of the influence of the social environment of housing estates was not substantiated by any form of estate stratification approach. These limitations undermine the authenticity of his findings.

Certain inadequacies persist which bear upon the usefulness and reliability of the findings in all of these studies for practical purposes:

- The studies were conducted with a pre-conceived notion of which factor(s) should be investigated. In order to gain an accurate perspective of maintenance expenditure behaviour, exploratory synthesis and analysis need to be conducted to determine which factors are actually significant.
- Data collected were based on price charged for the work, which is a biased measure of maintenance need as it is usually made up of both the repair item and other items of costs which may be unrelated to the original repair item. Hence, it is not infrequent to have a gamut of redundant cost data in most of these studies.
- Existing studies dealt with the examination of independent and uncorrelated singular factors. It is not conceivable to think of individual factors as being free from interference within the larger system.

Despite the increase in awareness of the importance of maintenance to the construction industry, current analytical academic efforts have incorporated these inadequacies as a matter of norm. Furthermore, the mass of academic effort has concentrated on the mathematical along side statistical modelling of narrow problems or the minutiae of decision theory and forecasting. Among what is lacking and is the objective of this research, is the development of a framework of factors which govern maintenance need in housing stock.

The problem as it stands has been succinctly articulated by McGeorge and Betts (1990) as follows:

> "Building maintenance is dependent upon a number of factors ... Most of these factors are in some form of dynamic relationship with one another. The

> problem is in identifying these key factors given the uncertainty of ... the life cycle of a building".

With this typical problem is the added problem of the qualified nature of maintenance expenditure. This has a far reaching effect upon the usability of historic maintenance cost data for research purposes. One must therefore look elsewhere by way of methodology to complement existing historic cost data.

1.4 The choice of Manchester for the study

The decision to use Manchester is more logical than sentimental. It is believed at the on-set of the research that the information required for the study was not going to be limited to qualitative primary data which are usually obtainable with minimum confidentiality restrictions from respondents. In addition, substantial quantitative data of some confidential sort will also be required.

In most, if not all housing organisations, records of maintenance expenditures are stored in computer software which can only be accessed with the use of 'password' only available to a few individuals within the organisation. It was anticipated therefore that such information will not be obtainable from any organisation which is not acquainted with the person requiring the data. Whilst the study could attain some width, its depth could be seriously hampered without a complete information set of both quantitative and qualitative data.

The use of one single organisation is beneficial as it enhances the use of homogeneous data set which allows for the specific variables of interest to be examined without undue interference from organisational variability. Furthermore, Manchester housing situation has been described by Short (1982) as broadly representative of housing condition in the UK.

1.5 Aims of the Research

The overall aim of the research is to develop a framework of factors influencing maintenance requirements in public sector housing.

To achieve this overall aim, the preliminary research (described in chapter 2) identified that the following areas needed to be investigated:

1. Nature and characteristics of maintenance cost records - development of a methodical approach to assessing overall maintenance requirements of housing stock.

2. The characteristics of local authority tenants

3. Housing stock condition assessment as perceived by responsible building surveyors

1.6 Research Hypothesis

To ensure the research aim was achieved, the following hypothesis was addressed throughout the research:-

Maintenance requirements are influenced by:

(i) a number of precise building object attributes;
(ii) the surrounding environment in which dwellings are located;
(iii) the characteristics of the tenants; and
(iv) housing management responsiveness.

The formulation of this hypothesis is discussed in chapter 2

1.7 Benefits of the Research

The study will be of benefit to individual building surveyors, housing managers, those involved in housing construction and design, and clients of the construction industry as follows:-

- Awareness and knowledge of issues bearing upon maintenance requirements should be of value to the individual housing managers at both estate and policy formulation levels.

- Housing organisations could become more knowledgeable about optimum maintenance strategies, and may become more attuned to users' needs.

- For the construction industry as a whole, a conglomeration of factors having significant influence on maintenance requirements will enhance judicious allocation of limited funds to maximum effect.

The isolation of groups of components that are meaningfully related should benefit architects and surveyors who are involved in various forms of design. It should assist them in evaluating groups of components prone to common or identifiable defect causing influence.

1.8 Organisation of the chapters

Chapter Two discusses the research methodology, the scope and methods of data collection. The strategy for the procurement of the research and working hypotheses are presented.

Chapter Three discusses the history of housing in the UK through the instruments of Housing Acts.

Chapter Four reviews various definitions of maintenance advanced by exponents and discuses terminologies for describing various grades of work to existing buildings.

Literature review of maintenance requirements indices used in the research is made. Chapter Five is the review of related literature on maintenance factors.

Chapters Six, Seven and Eight present the data obtained and the outcome of hypotheses testing, and resulting factorial models. The study is concluded in Chapter Nine.

CHAPTER 2
METHODOLOGY

2.1 Introduction

This chapter sets out the research methodology adopted for the study. Part of the problem lies in the nature of the subject matter; building condition and usage, involving a myriad of variables, cannot be examined separately from its social and economics context. Consequently, it is an exceedingly complex problem. Equally troublesome is the existing level of measurement. The inherent limitation of historical data has been aptly noted by Christer (1982), Bishop (1984) and Bird (1987). They all maintained that historical cost alone is not reliable for predicting future maintenance costs.

Tucker (1990) was of the opinion that maintenance records lack adequate description of details and hence, associated costs of such omitted details. He therefore advised that everyone seeking to make judgements based upon such data must exercise serious caution as historical data tend to be an underestimate. The observation about inaccuracy and unreliability of historical maintenance information has become too overwhelming to ignore. If they are typical of available records, unless rigorous manipulative measures are taken, there will be little value in seeking any more historical case studies. The need for theoretical modelling techniques is therefore even more pressing if the costs of maintenance are to be properly planned in future. This same problem was recognised by Wyatt (1980) when he argued that the interpretations of maintenance cost information are complicated by the extent that improvement and repair obscure the actual maintenance cost.

In the face of this deficiency in quantitative records, rigorous inferential classification techniques are called upon in order to evolve a set of reliable explanatory variables involved in maintenance requirements.

2.2 The Research Approach

The first stage of the research consisted of planning a research approach in order to develop a framework of factors. This involved a literature review, brainstorming sessions and contacts with individuals with experience in housing. As a result of this stage the research areas, hypothesis and tools were determined.

2.3 Research Tools

To choose a strategy for empirical data collection, in addition to the literature, it is important to define clearly the nature and applicability of historic maintenance cost information available for the study.

The preliminary research identified three principal areas requiring investigation. These are then decomposed into smaller identifiable elements.

To address the research areas, use is made of a mix of quantitative and qualitative assessment of the condition of the housing stock. Each dwelling within the sample is considered on its own merit and then the overall maintenance cost profile over a period of five years is analysed. This analysis is complemented by a survey of the tenants of the stock to be examined. In addition, a generalist survey of housing stock within the council of interest is conducted through a sample of building surveyors working for the housing department.

A cross-sectional study of housing authorities across the UK was not considered necessary given the reasonably large size of dwelling population in Manchester Council, and the time and cost limitations placed upon the research. It is more useful and relevant however, to fine-tune the study to a level of detail as to afford discovery of systematic exhibited characteristics, if any, within the housing stock without undue inter-stock variations to the study. Hence, the choice of a case study for this research.

2.4 Research Framework

It is has been suggested that once a building is erected, the level of maintenance required to keep it physically and functionally satisfactory is principally influenced by a system of usage and environmental conditions rather than by the building dynamics. The system of usage and environmental conditions are regarded as those forces 'outside' of the building object which cause a series of stress action on it (Grassi *et al,* 1990). The building dynamics pertain to those building characteristics inherent in the building fabric, which are traditionally believed to predicate its physical and functional behaviour (Coskunoglu and Moore, 1990).

The development of thoughts on the relationships and hence the working hypothesis are illustrated in Figures 2.1, 2.2 and 2.3.

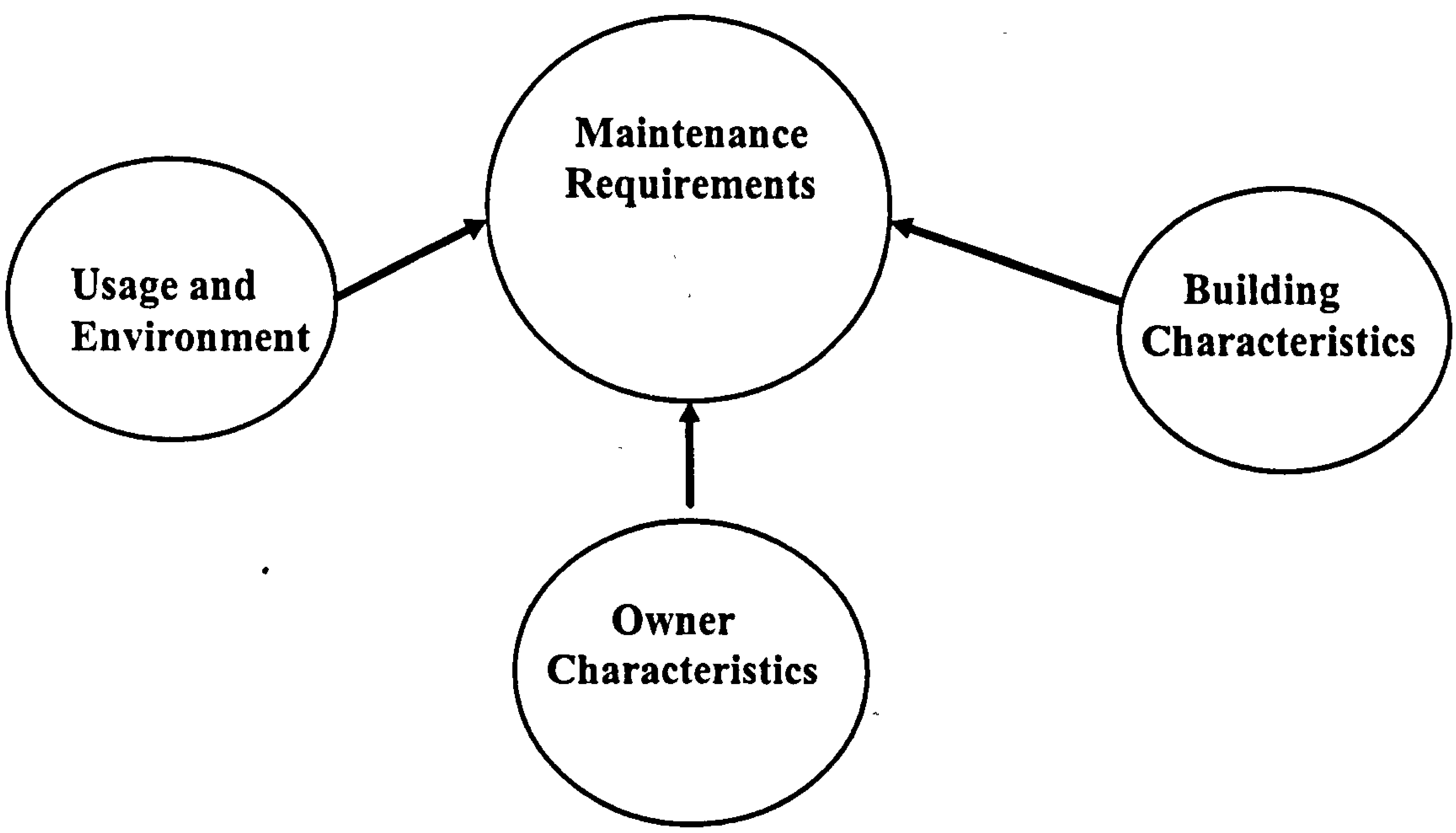


Figure 2.1: Forces impacting on maintenance requirements

These sets of positions can be translated into more tangible and less philosophical framework of influences as illustrated in figure 2.2.

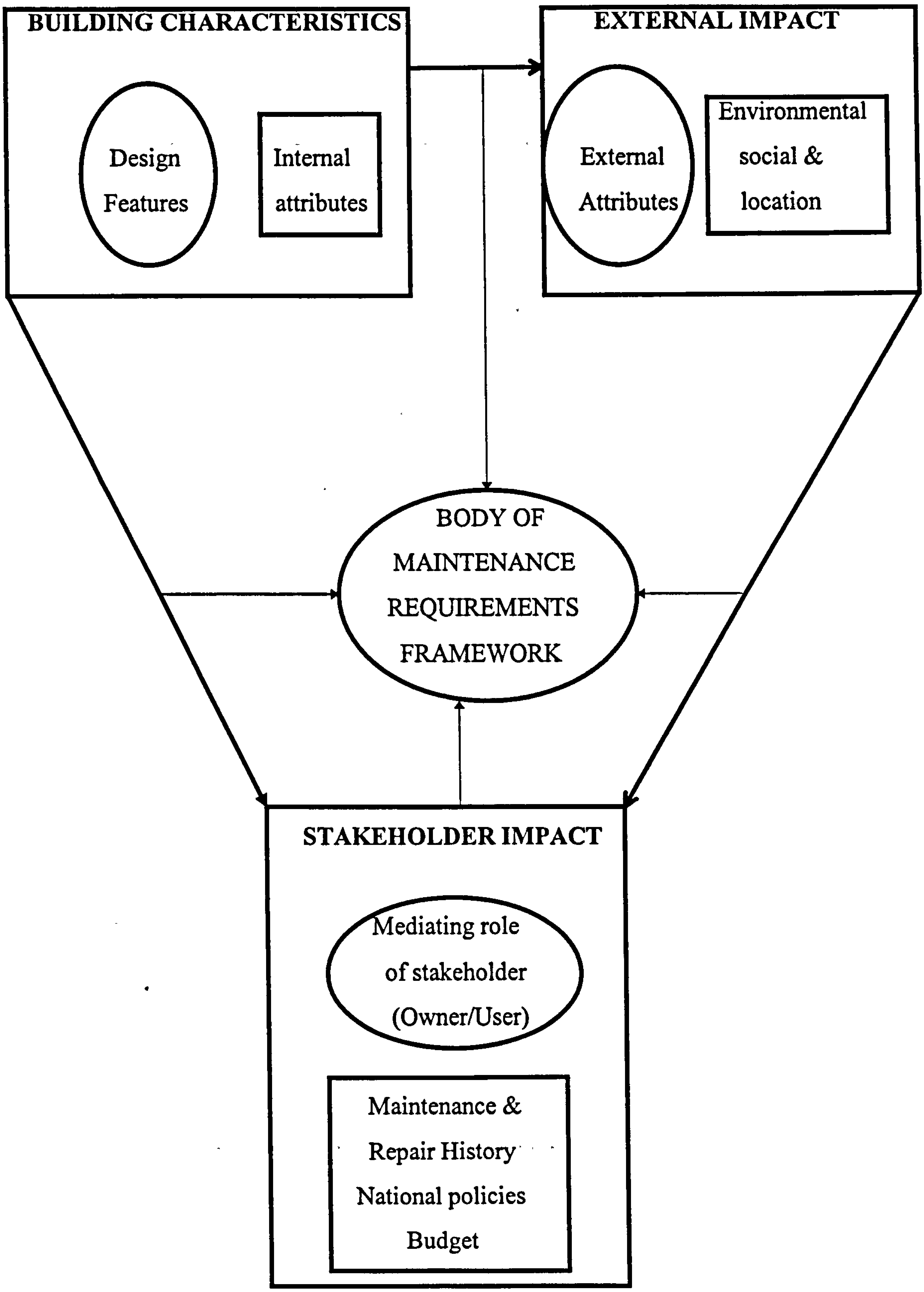


Figure 2.2: Interaction of factors in housing maintenance

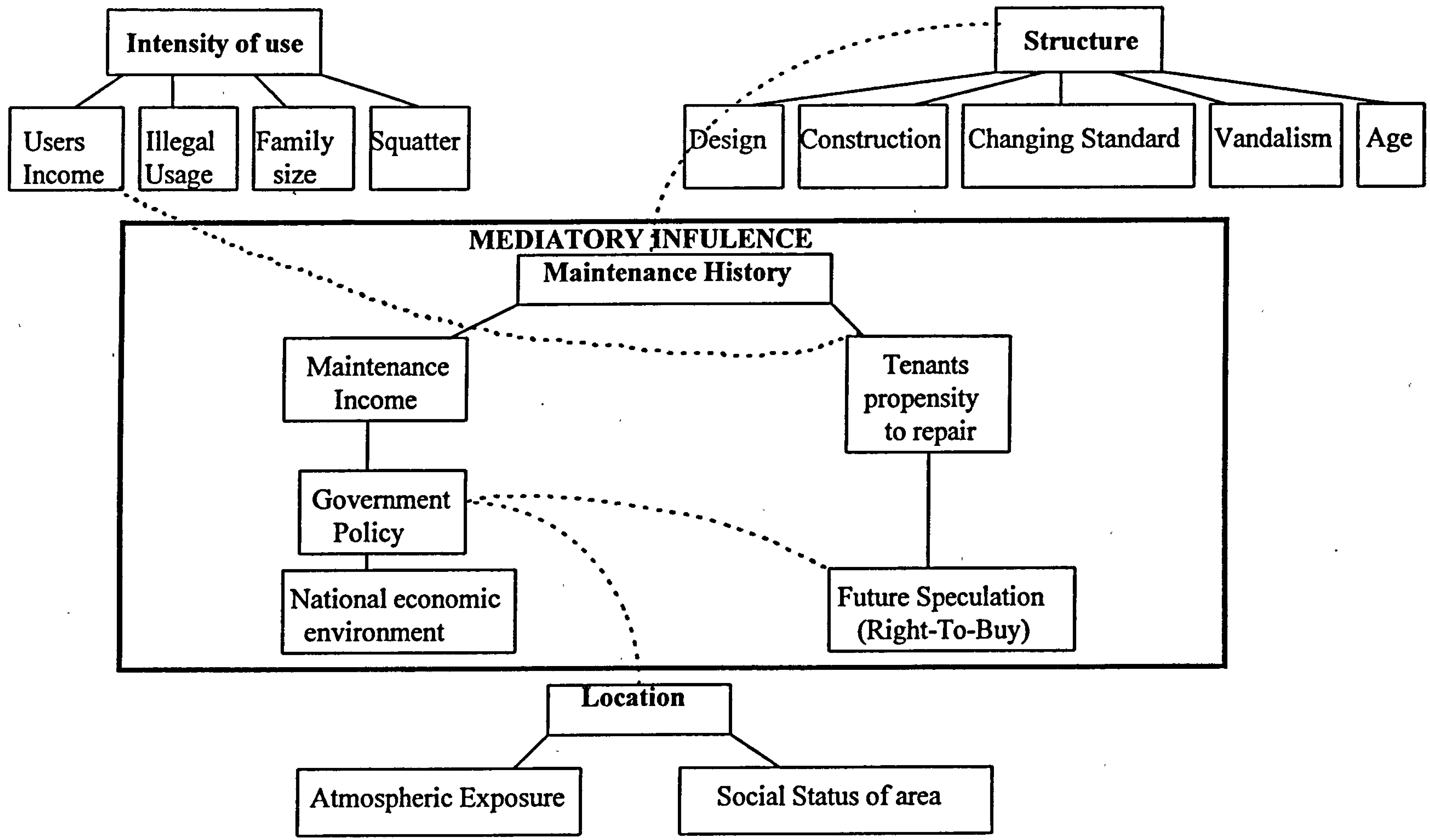


Figure 2.3: Model of factorial interactions in local authority housing maintenance

2.5 The working hypothesis

In the light of these interactions which come to light after an extensive review of literature in the subject area, (Figures 3.1, 3.2 and 3.3) the working hypotheses are stated as follows:

1. The internal attributes of a dwelling (building fabric) as defined influence its maintenance requirements.
2. The way the building is used and the environmental stress to which the building is conditioned influence its maintenance requirements.
3. The response attitude of the stockholder influences the stock's maintenance requirement profile.

Explanation for maintenance requirements characteristics to be meaningful should focus upon the primary generators of maintenance at individual stock level as a basis for any generalisation. The research scope has been selected with this in mind. Hence, the research has been broadly divided into three possible areas for the purpose of this investigation as shown in figure 2.2. That is, *internally generated attributes in housing stock, externally generated attributes and the mediating / response attribute of the stockholder.* All these possible areas are meant to complement one another towards the development of a framework for the set of parameters in maintenance need, if in fact they do exist.

2.6 Data Collection Strategy

2.6.1 Measurement and Statistics

Any kind of physical measurement made on living things will show variability across subjects. People differ in abilities, interests, attitudes, temperament, etc. Some of these individual differences can be measured more precisely than others depending on the type of scale on which they are measured. An initial step in the research method is therefore the measurement of the variables. Leedy (1989) describes measurement as the quantifying of a phenomenon which results in a mathematical value.

2.6.2 Nature of the Data

In the absence of absolutely reliable quantitative measures of the important concepts, recourse was made to classification techniques and pseudo quantitative measures. Random sampling technique is employed to ensure that the observations are truly independent.

Prodigious use is made of categorical variables in the study as they best measure truly discrete phenomena such as household size and attitude. In many instances, the research has had to compress variables into a small, manageable number of categories. This is a way to achieve mutual exclusiveness within the categories. According to Reynolds (1977) this is a fundamental requirement of most of the statistical techniques used in the analysis of data. An obvious problem with this need is that some continuous variables have to be compressed which may lead to erroneous conclusion.

2.6.3 Scales of Measurement

The measurement of physical and psychological variables can be characterised by the degree of refinement or precision in terms of four measurement scales (Aiken, 1991):

1. Nominal level of measurement divides the data into discrete categories. Any data that can be differentiated merely by assigning a name to it falls in this level of measurement.
2. Ordinal scale quantifies data or entity in terms of being of a higher or lower or greater or lesser order than a comparative entity but without specifying the size of the intervals.

   The above two categories together comprise the non-interval level of measurement.

3. Interval level of measurement is characterised by two features; equal units of measurements and an arbitrarily established zero point.

4. Ratio level of measurement which can express values in terms of multiples and fractional parts. It has an absolute or true zero point which is the total absence of the quantity being measured.

The interval and ratio levels together comprise the interval level of measurement.

The questionnaire survey instrument employs combined usage of the ordinal, nominal and interval scales. This is so as most of the attributes being measured are either attitudinal or opinion based which more readily lend themselves to the less precise ordinal and nominal scales.

Where appropriate, some of the non-interval measures have been converted to interval scale by some appropriate transformation techniques (after Kearns *et al*, 1991). This is a common practice in social and medical sciences. Many researchers believe that this practice does not lead to erroneous conclusions. According to Reynolds (1977), statistics such as tests of significance or measures of association apply to numbers as numbers and do not depend for their validity on the measurement model. According to him empirical evidence abounds that violations in measurement assumptions do not cause many mistakes in significance tests or parameter estimation. He alluded to Labovitz's (1970) assertion that correlation coefficients are more or less unaffected by applying them to ranked instead of numerical data, thus leading to the conclusion that parametric statistics can be given their interval interpretation with only negligible errors when used on ordinal data.

2.7 A framework for the measurement of maintenance need

2.7.1 Approach to preliminary investigations

The objectives of the preliminary investigations are twofold.

1. To identify the suitability or otherwise, of historic cost records for use as the dependent variable for the study.
2. To devise a valid list of independent variables. To achieve this, the survey will seek consensus agreements on a commonality of approach in housing property defect identification among building surveyors and housing managers.

2.7.2 Measurement of maintenance need

A major concern among researchers is that the tests be useful and that they measure what the authors claim (Aiken, 1991). Finding a reliable and consistent index or indices for measuring actual maintenance requirements of a housing unit is pivotal to any useful elicitation of the general behaviour pattern of the phenomenon.

2.7.3 Maintenance cost records

The approach of historic cost data analysis for the identification of influential factors was considered and exploited at the initial stage of the study. This was gone into in common with previous works in the field (Bird, 1987; Holmes, 1985; Bromilow, 1984; and BRE, 1972) with a view to adapting these data in a manner unique to this study, in order to determine the significant factors bearing upon the data. To this end, cost data spanning a period of five years was collected for some 66 council dwellings by way of preliminary pilot study. A breakdown of the two dwelling types employed for the initial study is shown in Table 2.1.

Table 2.1: Frequency distribution of the two dwelling types

Dwelling type	Frequency	Percentage
Semi-detached house	30	45.5
Cottage flat	36	54.5
Total	66	100

Table 2.2: Analysis of Variance of repair costs

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	132872.9293	132872.9293	.0429	.8366
Within Groups	64	198331896.1	3098935.876		
Total	65	198464769.0			

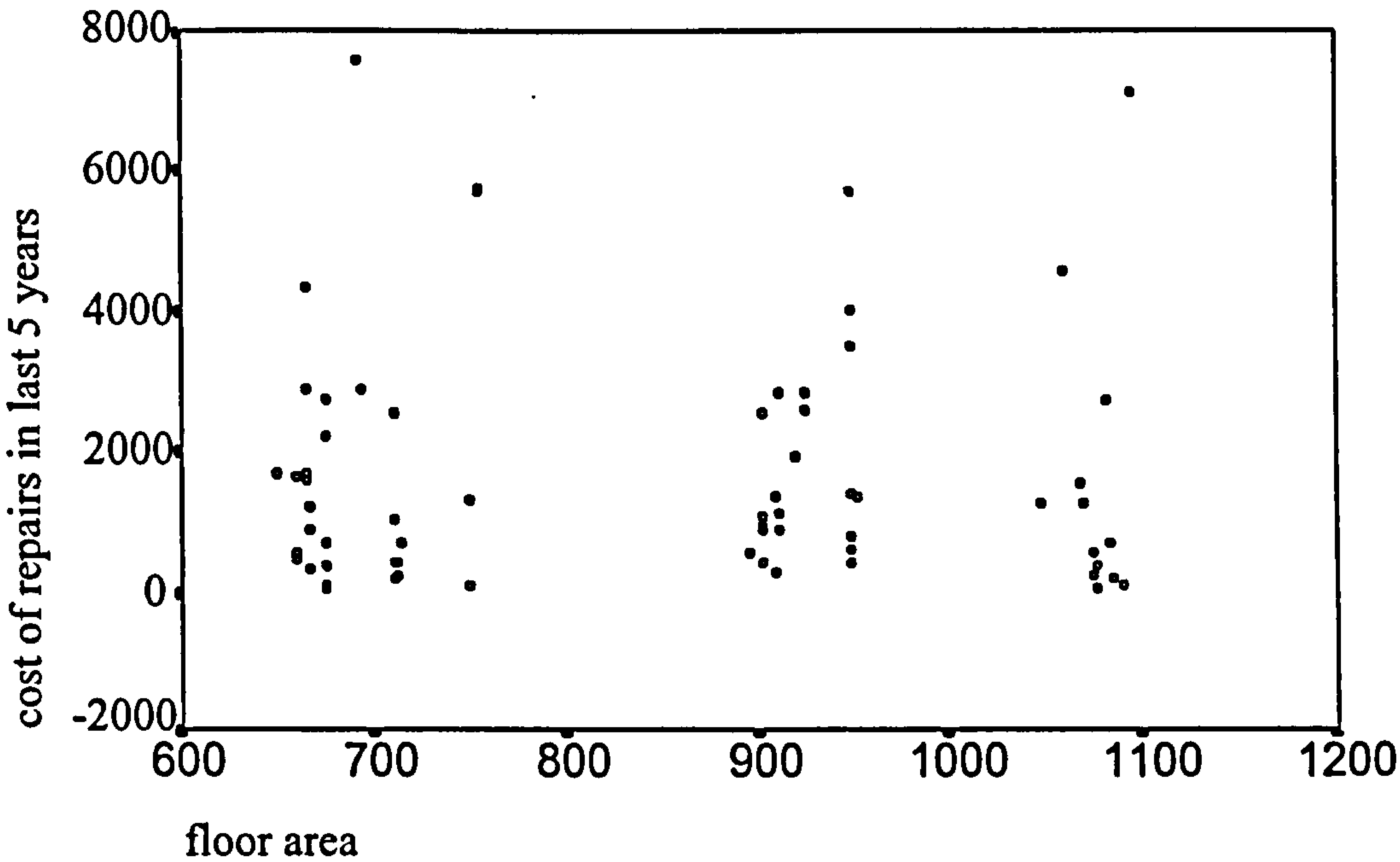


Figure 2.4: Scatter plot of dwelling floor area vs repair costs

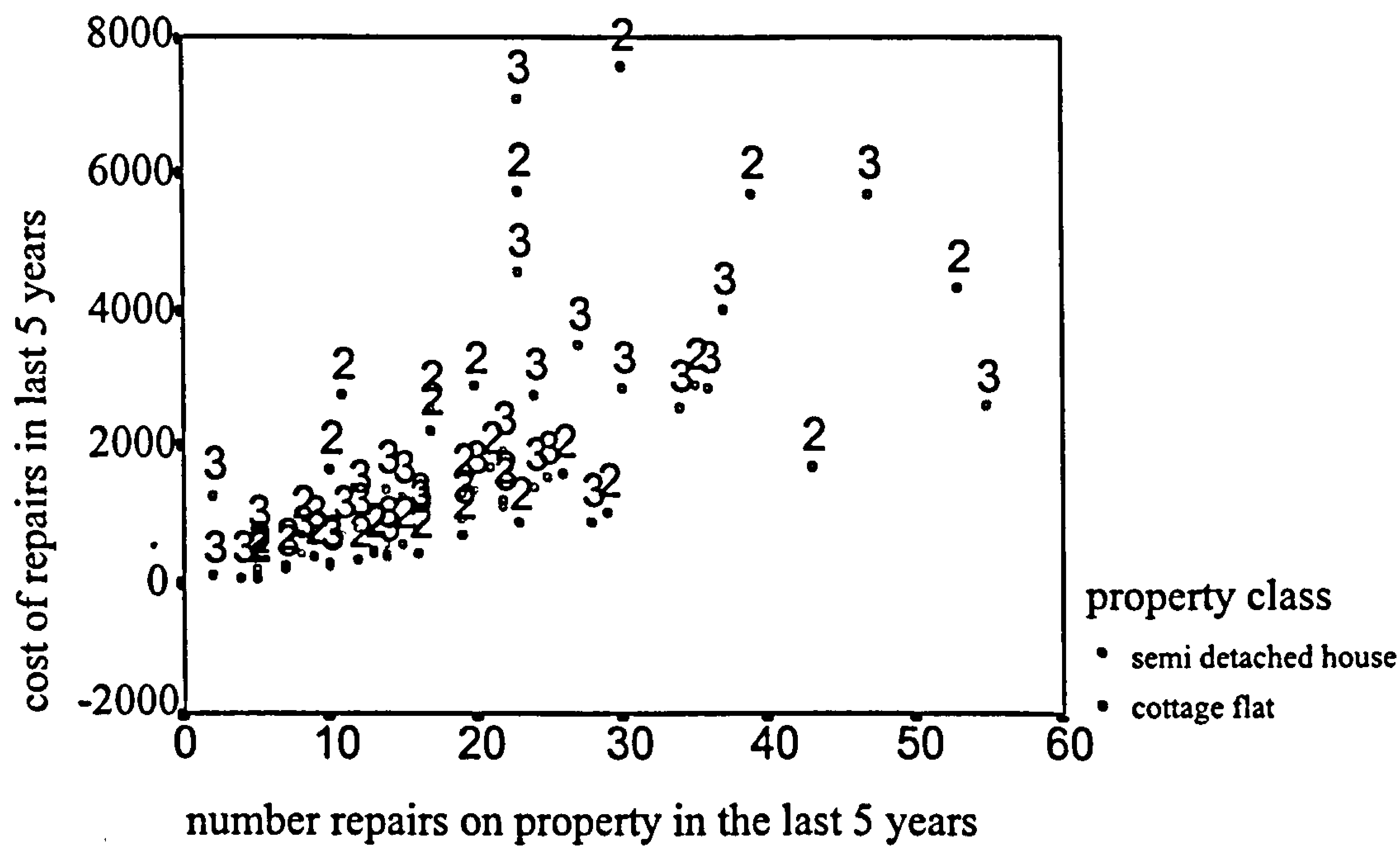


Figure 2.5: scatter plot of defect count vs repair cost

The sample consist of 30 three-bedroom semi-detached houses and 36 two-bedroom first floor cottage flats chosen from the same house parcel from the South of Manchester. The idea was to minimise variability within each selected dwelling type.

An Analysis of Variance of repair cost over a five year period for the two dwelling types shows no significant difference (see Table 2.2). Given that the two dwelling types are disparately different in terms of design and tenants' classification, this lack of pattern is a cause for concern. The absence of pattern in repair costs over the period is graphically portrayed in Figures 2.4 and 2.5. They show that repairs are not patterned after dwelling size in terms of floor area or number of bedrooms in a dwelling. Therefore, there was the imminent problem of either including too few factors which would result in the loss of interpretable factors or including too many factors thereby causing factor splitting thus resulting in pseudo-specific factors.

This methodological deadlock was not surprising in view of an earlier experience by Spedding (1987a) that previous studies have abundantly demonstrated that "maintenance costs do not relate to actual need, but to policies dictated by financial priorities decided at the time of carrying out maintenance". This assertion tends to demonstrate possible lack of pattern in maintenance costs as a datum for any meaningful analysis.

In the light of this potential problem with hard historical cost records, the option of qualitative assessment of a housing stock was considered. In this exploit, each dwelling is taken on its own merit. The overall maintenance items generated overtime from both the tenant and council's technical staff were investigated bearing in mind the differential attitudes of individual tenants. This necessitated questionnaire surveys of both the tenancies of the stock to be examined and building surveyors involved in the day to day identification of defects on housing stock in the Council, and an environmental assessment of each dwelling (after Crosby, 1985).

2.7.4 Problems with cost records as a basis for the measurement of maintenance need

How do we measure the maintenance need of a property? The inadequacies of maintenance cost records as yardsticks for measuring requirement are exhaustively documented (Mole, 1992), (Brown and Robertson, 1990), (Spedding, 1987b), (Hollis and Gibson, 1986), (Christer, 1982), (Stone, 1980) and (HMSO, 1976). In the absence of maintenance cost as an effective measure one is led to consider the total number of defects generated by the property through time as a ready-made objective indicator. For this to be an efficient and valid measure, it must be established that every defect reported by whatsoever means is equally important. To do this, the pattern and distribution of the mean cost of defects in each dwelling included in the final survey were studied. The closer to zero the standard deviation of the mean is, the more accurate it will be to assume that any two defects identified are equally important, at least in terms of cost. For example, given the following statistics (Mean=1413.12 and S.D.=1517.75), the deviation is considered too high to allow for any assumption of proximity within defects. Hence, it was decided that simply using the number of defects as a measure of maintenance generated by a property cannot be a valid or efficient index.

Further to preliminary interview with housing management team, the mechanism for the identification of defect introduces a new dimension to the problem of using either maintenance cost or number of defects for this purpose. It is useful to know that the problem which impacts upon the criterion of interest has nothing to do with the pricing mechanisms as identified by (Stone, 1980). Any problem connected with this phenomenon is believed to have been taken care of by the homogeneity created by the use of a case study (this makes pricing error a common denominator to the data). The real problem lies in the way and manner defects are identified and the criteria for actioning defects schedules prepared by surveyors:

1. The more aware tenants are of their rights, the higher the cost records associated with his/her dwelling. This disposition among tenants will, more than anything else, be dictated by whether or not the tenant is entitled to legal support.
2. The degree to which pressure is generated by the tenant on local housing management depending upon user satisfaction and tolerance levels.

Whilst the total number of defects over time is less useful because of lack of validity and efficiency, it would be tantamount to throwing the baby out with the bath water to discard existing cost records on the ground of being totally useless. Given some vital adjustments which can correct for existing anomalies in cost records, its validity and efficiency can be substantially improved as to render it a more useful index. To achieve this objective, it was decided to corroborate existing cost data with a further survey of each dwelling in the sample (see chapter Eight).

2.7.5 Preliminary questionnaire design and surveys

The rest of this chapter describes both the introductory questionnaire survey (the preliminary survey), and the final questionnaire survey (the final survey) for this study. The objective of this section of the report is to ascertain the relevance or otherwise of the factors included in the study as independent variables.

The preliminary survey was conducted during the early stage of the study following an extensive literature search on the subject. The final surveys were conducted to establish the observations and to justify or refute the hypothesis developed from the theoretical background work and preliminary questionnaire.

2.7.5.1 The preliminary survey - Data collection and subjects

In appraising any set of attributes, the attributes should be discussed almost ad nauseam (Fortune and Skitmore, 1994) with the individuals who practise (in this case, the building surveyors), as well as those for whom they are responsible (in this case, housing management team).

In view of this, it was considered appropriate to gather views from both building surveyors and housing management officers in the first instance, and subsequently from housing tenants in order to gain a rounded understanding of the subject of maintenance need.

Research data was collected from the first two groups of subjects namely; building surveyors and housing management team. The rationale for this was that of the three groups identified, building surveyors and housing management team have a deep dimension of impersonal interest in the stock by virtue of their professional training and background. Whilst tenants have a highly variable but personal interest in their respective properties. Since what is desired at this stage is an unbiased view of the issues involved, it was not considered appropriate to involve tenants at this stage of the study.

An important characteristic of the subjects in the preliminary survey is that the researcher has worked with both the building surveying and housing management teams at one time or the other in the last five years in his role as a principal surveyor with the Council. The team have, therefore, been selected for this crucial part of the study based upon their perceived individual competence and experience with the council housing stock.

The building surveying group comprised 15 building surveyors. The housing management team comprised 17 housing officers. All the subjects were visited on appointment between February and June of 1993. A very brief interview and rank order schedule (after Kerlinger, 1973) were used to collect the data from the two subject groups for this part of the preliminary study.

2.7.5.2 Procedure for the preliminary survey

The introductory survey was conducted with building surveyors and housing management officers, all of whom are primarily employed to look after the council housing stock. The survey instrument was designed in the form of a questionnaire but the implementation took the form of a structured interview, which meant the author, read the questions and ticked the answers for the respondents.

Questionnaires as in Appendices 1AA and 1AB were used to obtain data from each of the two groups of subjects. Basically, identical procedures were used in the collection of data from the different groups, consisting of the following.

1. A general introductory informal discussion with the subjects concerning the nature and purpose of the study and the concept of defect. For the building surveying segment of the sample, briefing session was somewhat superfluous as they are well informed and trained in the technicalities of defects and maintenance. Nevertheless, the briefing

exercise was a means of creating a uniform basis for response and mitigating the problem of subjectivity among surveyors (after Damen, 1990). For the local housing management team, the exercise was as vital as it was educative.

2. Subjects were then asked to rate the factors on their level of importance in contributing to maintenance generated on a dwelling. A number of factors were purposely repeated in such a way that it would not likely be detected by the subjects as control factors to measure the consistency in the response of each subject (after Latham and Saari, 1984).
3. Each subject was given the opportunity to comment or add to the list of factors that they were presented with, and then rate such factors on the same basis.

The total time taken for each of the interviews ranged between 20 and 30 minutes and it was generally found that this was an appropriate period for maintaining interest and motivation during the exercise. Each subject was asked to rate on a scale between 1 (very important) and 3 (not important) the importance of each of the listed factors. No information was given to the subjects on the results of the interview and no communication between subjects took place in the process of the data gathering.

2.7.5.3 Results of preliminary survey

In Question No. 1 participants were asked about the nature of their work. On analysis, the sample consisted of 15 building surveyors and 17 housing management officers.

Question No. 2 related to the length of time the participant had worked with the local authority in the role identified in Quesiton No. 1. The breakdown of response is given. The mean period of service among building surveyors is 9.5 years with minimum 5 years, and maximum 15 years; whilst those of housing management officers are 7.9 years, 5 years and 12 years respectively. In general, it would appear that participants are well experienced in their respective jobs, and hence can be depended upon to provide seasoned and accurate considered opinions on questions.

Between the 15 building surveyors who participated in the preliminary survey, a total of 7,800 properties which represent some nine per cent of the total housing stock owned by the council have been surveyed in the last five years. It is possible that some of the properties have had repeat surveys carried out on them, but should not be detrimental on these results.

Between the 17 housing management officers, 4,500 dwellings (5 per cent of total stock) are managed all across the city.

Question No. 4 was intended to highlight the existence of bogus reporting of defects which may be on the one hand by informed tenants about improved chances of getting work done during particular periods of the year, and on the other hand, by housing management team where moratoria have been set and there is constraint either not to exceed (in which case requests for defects are not responded to) or a need to achieve spend (in which case works requiring expenditure are premeditatedly searched out).

The building surveying analogue of this question is to serve as a control question to establish the validity or otherwise of the housing management participants' response.

Question No. 5 provided a comprehensive list of factors largely based upon the research framework. The response to this catalogue of factors was considered to be a sound basis for discriminating between which factors should be included in the final set of questionnaires on one hand, and the choice between whether or not a detailed questionnaire survey of council housing tenants was justifiable.

The current position is that there is no clear indication about which building and social related factors significantly affect maintenance requirements. In all, there is a gamut of possible factors which have been advanced, albeit in exclusive isolation of one another. Sanders and Thomas (1992) suggested that a compromise must be established between analysing all possible factors and not considering any. This requires that the significant factors be identified. No previous procedures have been developed to both "identify and quantify" the effects of any of the factors other than age (Alners and Fellows, 1990).

The two-pronged approach to factorial discrimination (whereby data are gathered from two different groups of professionals for the same set of factors) is unique to this study and is believed to be beneficial in evolving an order out of what would have been a chaotic array of factors - most of which do not lend themselves to any systematic quantification.

2.8 Final Questionnaire Design and Administration

2.8.1 The sampled Population for the final surveys

The methodological problems of surveys fall into three broad groups namely; from whom to collect information, what methods to use for collecting it and how to process, analyse and interpret it.

The final survey was divided into two segments. The first sought to elicit information on 'the building object' defect and maintenance within a chosen local authority setting herein referred to as 'surveyor questionnaire'. The second elicited information from council tenants across the city, and it is herein referred to as 'tenant questionnaire'.

2.8.2 Information Sourcing

This section identifies the sample population and sample frame for the study. In studies of this nature, Egbu (1994) suggested that the population sample needs to be homogeneous, comprehensive and must be truly representative of the entire population. The process of sampling, or the selection of part of the population from which the characteristics of the larger population are inferred, has long been accepted as a legitimate and expeditious method of research (Egbu, 1994), (Schuessler, 1971), (Lawson et al, 1975) and (Walker, 1985).

Sampling theory distinguishes between 'probability' and 'non-probability' sampling (Kidder and Judd, 1986; Cochran, 1976). In the former, every subject in the population has a known, non-zero probability of being included in the sample. In the latter, the probability of inclusion of each subject is not known and many of the elements may have zero probability (Kidder and Judd, 1986). In considering the sampling of a population, due regards are paid to the purpose of the survey. This study involves seeking the opinions of building surveyors engaged in the diagnosis of defects in

Manchester City Council's housing stock. Hence, the sampled population in this case was restricted to building surveyors employed by the Manchester City Council, thus implying that the adopted sampling technique belongs to the non-probability methods of sampling.

Non-probability sampling works in a number of ways (Cochran, 1976). Of these, the followings are the most relevant to this study:

a) It confines the sample to an easily accessible part of the population.

b) It seeks volunteers in cases where the investigation could be burdensome to the people approached.

2.8.3 Building surveyor's questionnaire

2.8.3.1 Sampling for the surveyor's questionnaire survey

The sampling carried out in this study was deliberately limited to building surveyors in Manchester City Council (who have responsibility for identifying and diagnosing defects on housing stock, among other properties) large enough to be effectively independent, and therefore capable of being seen as system in its own right. The sampling also relied on volunteers for response, given the technical complexity of the questionnaire. By this conscious and deliberate choice, compatibility with Cochran's (1976) features of non-probability methods of sampling was achieved.

One hundred questionnaires were sent to building surveyors across the city. It should be noted that these represent a wide spectrum of experience. The questionnaires were mailed by the City Council's internal mailing system. The names of these surveyors were obtained from the staff list of the Direct Works, City Architect and Housing Department.

2.8.3.2 The Field Survey

A field survey was conducted among buildings surveyors as in section 2.8.3.1. This could be done by collecting data through personal interview, telephone interview or by written questionnaire. Each method has its advantages and disadvantages which the researcher must evaluate for their suitability to the research question and to the population concerned (Bouchard, 1976), as well as for their relative cost and time.

Personal interviews are the most costly both in terms of cost and time. Barring the prohibitiveness for cost reasons, this method is highly plausible for the study, especially as the participants are all located within a defined and narrow geographical bound.

Telephone interviews would not possibly have been less costly, and therefore also prohibitive. Furthermore, since a complex and detailed questionnaire was to be put to the surveyors, this method was clearly precluded for impracticality.

From the foregoing, the decision was to use a hybrid of mail questionnaire. Mail surveys have been criticised because response rates are often low, with the attendant problems of response bias, wording of questions, as well as the inability of the investigator to verify the information provided (Walker *et al* 1987; Kanuk and Berenson 1975; Kerlinger 1973; Adams 1956). The continued use of the technique suggests, however, that the advantages such as being able to cover a wide spread of sample of participants, administer the work simply, complete it in leisure time, and maintain personal confidentiality, outweigh its limitations. In using this technique, the main objective is to obtain quantitative data, which are otherwise unobtainable, thus, facilitating statistical testing of the research hypotheses.

2.8.3.3 Design and content of the Questionnaire

The choice of the 28 building components was made by an examination of repair headings in the Direct Labour Organisation computer cost records. These components are considered to be sufficiently frequent in the stock for every surveyor to understand what each of them refers to. They are also considered to be highly representative of defects in the council stock. From the initial examination conducted (section 2.7.3) over 80 per cent of repair headings are classified under the selected 28 component items.

There is a plethora of literature on guidelines for the design of an effective questionnaire. Kidder and Judd (1981) and Dillman (1978) provide comprehensive suggestions on the process of questionnaire design, structure and administration.

A questionnaire is an effective instrument for observing data beyond the physical reach of the observer. It also serves to sample the opinion of individuals in spatially diverse locations. It can be economical and expeditious if designed along certain guidelines. These include using unmistakably clear and courteous language, designing the questionnaire to fulfil a specific research objective, simple expressions, brevity, checks for consistency and an offer of the results of the study to the respondent.

The twenty-eight building components on which respondents are to express their opinions on defects occurrence and causes on five-criterion model, are considered too numerous to allow objective measurement for them to be practically used. Moser and Kalton (1971) and Kidder and Judd (1981) have shown that the measurement of relatively subjective phenomena may require as many as 15 or more questions for a single variable alone in order to elicit the full intensity of attitude or opinion. Thus, on the same scale, the questionnaire for this study would have required an unmanageably huge number of (28 × 15) questions for each of the five criteria.

It was decided to devise an inventory of building components on which defects are manifested, instead of asking component defect or maintenance need questions on each component for each of the five-criterion levels. To achieve this, it is important to have a layout which is suitable for respondents to rate themselves with speedy completion (Gael, 1983) rather than a question and answer approach. Listing components against defect causing criterion as opposed to asking component defects and maintenance need questions, has the advantage of allowing respondents to *concentrate and focus on the* *object* of the survey. Furthermore, as respondents could identify with the object of the survey, for reason of robustness in its layout, this approach could have contributed to increasing the number of responses. It is however worthy of note that a possible disadvantage of this approach to questionnaire layout and structure is the fact that the researcher runs the risk of conditioning a respondent's responses. This potential draw-back was not however observable from the pilot study conducted.

2.8.3.4 Piloting questionnaires for surveyors

Prior to sending out the final draft of the questionnaire to respondents, the questionnaire was pre-tested to ensure that the instrument met the essential guidelines discussed in the preceding section. For instance, a pre-test helps to verify whether the questionnaire expresses clearly what the researcher expects from the respondents. The approach adopted followed that suggested by Dillman (1978), who recommended that piloting should include different groups, such as colleagues, and potential users of the data.

The initial draft of the questionnaire was presented to colleagues, who on this occasion were the potential users, i.e. building surveyors with the city council.

Questionnaires were sent out to six surveyors - representing three to each of North and South area offices of the city. After one week, four completed questionnaires were received. One of the respondents pointed out that a score of '5' for 'Not sure' can be misleading and therefore suggested that '0' in place of '5' should be more desirable. One of the two respondents who did not return his questionnaire after one week decided to bring his partially completed questionnaire in person along with guidelines for developing a more effective questionnaire survey instrument. He suggested that the preamble to Q4 be re-written and that the words for occasional, often, frequent and constant were confusing. Instead, he suggested that they were changed as follows;

Hardly ever	-	0	Very occasional	-	1	Occasional	-2
Frequent	-	3	Very frequent -	4.			

Apart from these comments and suggestions, the respondents were of the opinion that the questionnaire was well structured and should be understandable to the target population.

2.8.4 Tenant's Questionnaire

2.8.4.1 Sampling for the tenants' questionnaire survey

The sampling carried out in this segment of the study was limited to tenants with Manchester City Housing Department. The house building stock from which the sample is selected is large enough to be effectively independent, and therefore capable of being seen as system in its own right. The sampling also relied on unsolicited voluntary response from tenants, given the vastness and varieties in the population of interest. By this conscious and deliberate choice, compatibility with Cochran's (1976) features of non-probability methods of sampling was achieved.

Six hundred questionnaires were sent to tenants across the city. The selection of the sample was based upon the method of stratification (after Walker, 1985) on the basis of house type so as to ensure a fair representation of every house type within the dwelling population. Following from the stratification, the probability sampling technique (after Kidder and Judd, 1986 and Cochran, 1976) was adopted. The questionnaires were mailed by the City Council with their letter heading. This, doubtless, facilitated and enhanced high response rate.

2.8.4.2 The Field Survey, and design of the questionnaire

A field survey was conducted among a large number of tenants with the council. In the light of section 2.8.4.1 above, the decision was to use mail questionnaire.

The variables of interest in the study are by their nature too technical for the average respondent in this segment of the study, and hence the need to express most variables in such a manner understandable to the respondents. This need necessitated that the questionnaire was designed to be in a close-ended format where practicable to do so; that is, it prescribed for each question a specific choice of responses. This is usually a very satisfactory way of obtaining data. Among its main advantages are that close-ended questions are easily coded to produce meaningful results for analysis; and response categories are provided, which may help to clarify the point of the question for the respondents, or assist their memory (after Bufaied, 1987). This is a desirable attribute for the type of subjects being dealt with in this instance.

The questionnaire was intended not simply to obtain an opinion but to discover how strongly it was held. Therefore, where appropriate, answers were requested to be given in accordance with the Likert point-scale indicating the strength of the view held. One of such point-scales is shown in Table 2.3.

Table 2.3: The Close-Ended questionnaire Likert scale format

Strength of opinion	Scale
Very likely	4
Likely	3
Unlikely	2
Very unlikely	1
Don't know	9

Bufaied (1987) concluded, based upon some previous researchers' arguments, that people are capable of making distinctions on a scale as wide as 7 points. Moser and Kalton (1971) have reported reliable results with a scale of 5. Youngman (1978) also affirmed that it is not always easy to rank more than 4 or 5 items. Taking account of the nature of the subjects, length of the questionnaire, and the need to improve the chances of response from tenants, it is believed that a five-point scale or even lower is a suitable choice. Moreover, advancements in computation and statistics make it feasible to derive valuable results from such a scale.

Questions were carefully framed to convey to the respondents what information is desired in order to ensure reliable responses. The questions were developed along the following guidelines (after Latham and Saari, 1984):

- They should be as short as possible, in language simple enough for the unread, and likely to be interesting to them.
- They should not be vague or irrelevant.
- They should be as indirect as possible without leading the respondent towards the answer.
- As people are always inclined, in answering questionnaire, to agree with what is thought to be the point of view of the inquirer, it should include some negative statements as a check for consistency. A contradiction in response to two differently framed questions would invalidate the point of view expressed in the questionnaire.

In the questionnaire which was devised, Question No. 3 was included as a check on Question No. 7. Discordance between the response to the former and the summary response to the latter, was sufficient ground for the rejection of a subject on account of carelessness in the filling of the questionnaire.

An initial draft of the questionnaire was sent to a selected number of tenants to safeguard the reliability of the instrument. Their comments and suggestions allowed a number of useful amendments to be made, thus improving the quality of the final instrument. These amendments consisted chiefly of avoiding technical questions which may not be familiar to the least informed of the tenants. The final instrument was then tested for clarity on a sample of 10 tenants and found to be workable. The questionnaire in its final form is shown in Appendix 1C

2.9 Exclusion of housing management team from the final surveys

This cohort of professionals possesses vital knowledge and experience of generalist nature on housing issues. However, they are not considered to possess technical knowledge to sufficient depth for the desired knowledge elicitation required in the final survey. In recognition of the width of their knowledge acquired chiefly by experience rather than by training, they have been involved in the preliminary factor elicitation as discussed earlier.

2.10 Summary

This chapter has described in detail the methodological approach adopted for the study. It also attempted to develop a framework for the research by identifying the prime areas requiring investigations. An extensive examination of the nature of housing maintenance data was carried out in order to determine suitable data classification, measurement and analysis methods for the study.

The methodology adopted chiefly comprised of data collection on repair costs and postal questionnaires which yielded a higher than average response rate for studies of this nature. This was preceded by pilot studies for the two sets of questionnaires. The problems encountered and the strategies employed to mitigate them have been discussed.

Overall, the methodology proved successful. The research method adopted has provided the kinds of information needed for the study. These information sets relate to local authority maintenance requirements in Manchester City and factors which influence them.

CHAPTER 3
HISTORICAL CONTEXT OF HOUSING IN MANCHESTER

3.1 Introduction

In criticism of this section, it may be said that undue emphasis has been laid on the historic context of housing, but M.C.C. (1947) expressed that 'right application of future principles can only be made in the light of successes and failure' of the past.

Historical perspectives of any city will always date back to the existence of man in the community. It is however not of particular import to this study to go as far back in time as medieval or even Victorian times in an effort to bring retrospection to the problem of interest in this study, as the germ of the housing maintenance problem is not found in too distant a past.

Up until the closing years of the 19th century, new house building was not considered by the state as a civic responsibility. This period was one of constant controversy over how far the state and the municipality should be responsible for the proper housing of the poorer classes.

The municipality's reluctance at taking on further responsibilities for housing according to Dale (1980), was demonstrated by Manchester's opposition to the passage of the Artisan and Labourers' Act of 1875. This was a permissive Act which went some steps further from the earlier Acts by contemplating clearance of slum areas and also gave the local government power to supervise and initiate local action. However, Manchester Council, in common with many other councils, showed strong objection on the ground of expense.

State and municipality involvement in housing first started by way of concerted elimination of some of the most pressing sanitary problems. The effort saw the formation of the Health Committee in 1868.

According to M.C.C. (1947), a fair summation of Manchester's housing progress during this earlier period was that, whilst the city authorities were slow to take advantage of housing legislation, they nevertheless were reasonably progressive in their efforts to improve housing conditions.

The 19th century's closing years saw the first attempts at introducing new for old housing, thus inaugurating local authorities' active participation as enablers and enhancers of housing in the UK as a whole (Bedale, 1980; and Malpass et al, 1993). The 1890 Housing of the Working Class Act aimed at urban housing. The Act empowered local authorities to acquire land and to erect or convert buildings suitable for dwelling-houses for the working classes. Because the adoption of the 1890 Act by local authorities was permissive rather than obligatory, it had only very limited impact. By the end of the century the housing problem in the UK was still both in a quantitative and qualitative sense (Burnett, 1978). The overall condition of housing at this point in time was summed up as being unhealthy, ugly, overcrowded house in mean street.

3.2 Manchester's stock

The Manchester City Council owns a large number of housing properties (see Table 3.1), which in 1994, numbered over 83,000 notwithstanding the decimating effect of the Right-to-Buy Act of 1980. These are spread through out the city, covering an area of about 11.5 hectares (44 square miles). About 23 per cent of these dwelling units are situated in eight neighbouring local authorities, commonly referred to as 'overspill' estates (Fletcher, 1990).

A broad range of design and construction types are represented in the stock, which makes Manchester's stock reasonably representative of the stock across the country. The stock is also representative of the overall physical planning and urban problems of typical English large cities (Fletcher, 1990).

Table 3.1: Dwelling distribution by type and year built

Age band	Height (up to 5 storeys	Multi-storeys	Houses	Total
Pre 1919	300	-	1168	1468
1919 - 1945	3949	-	19329	23278
1945 - 1964	8435	2517	14664	25616
1964 - 1974	5506	4115	10028	19649
1975 to date	6415	27	6828	13270
Total	24605	6659	52017	83281

3.3 Local authority and the implementation of housing policy

Housing policies are usually generated by the central government, whilst their implementation is more commonly effected by the local authorities. While the central government broadly determines the context of housing policies, the local authority gives shape, form and life to many of the policy directives (Short, 1982), thus becoming a link between the policies and their beneficiaries. However, because of the range of policy options and the level of discretion, the local authorities have a degree of choice in policy implementation, which, when exercised, produces variations in housing policy impact across the country. Figure 3.1 illustrates the central role played by the local authorities both as conveyors and agent for implementation of housing policies

Two main sources of variations in local authority implementation have been identified as follows (Short, 1982):

1. The history and geography of the local authority. For example, Manchester has been described as a city with an old, outworn, housing stock.
2. The political hue of the local politicians. In general, Labour-controlled authorities tend to spend more on local authority housing and emphasise state involvement in housing matters.

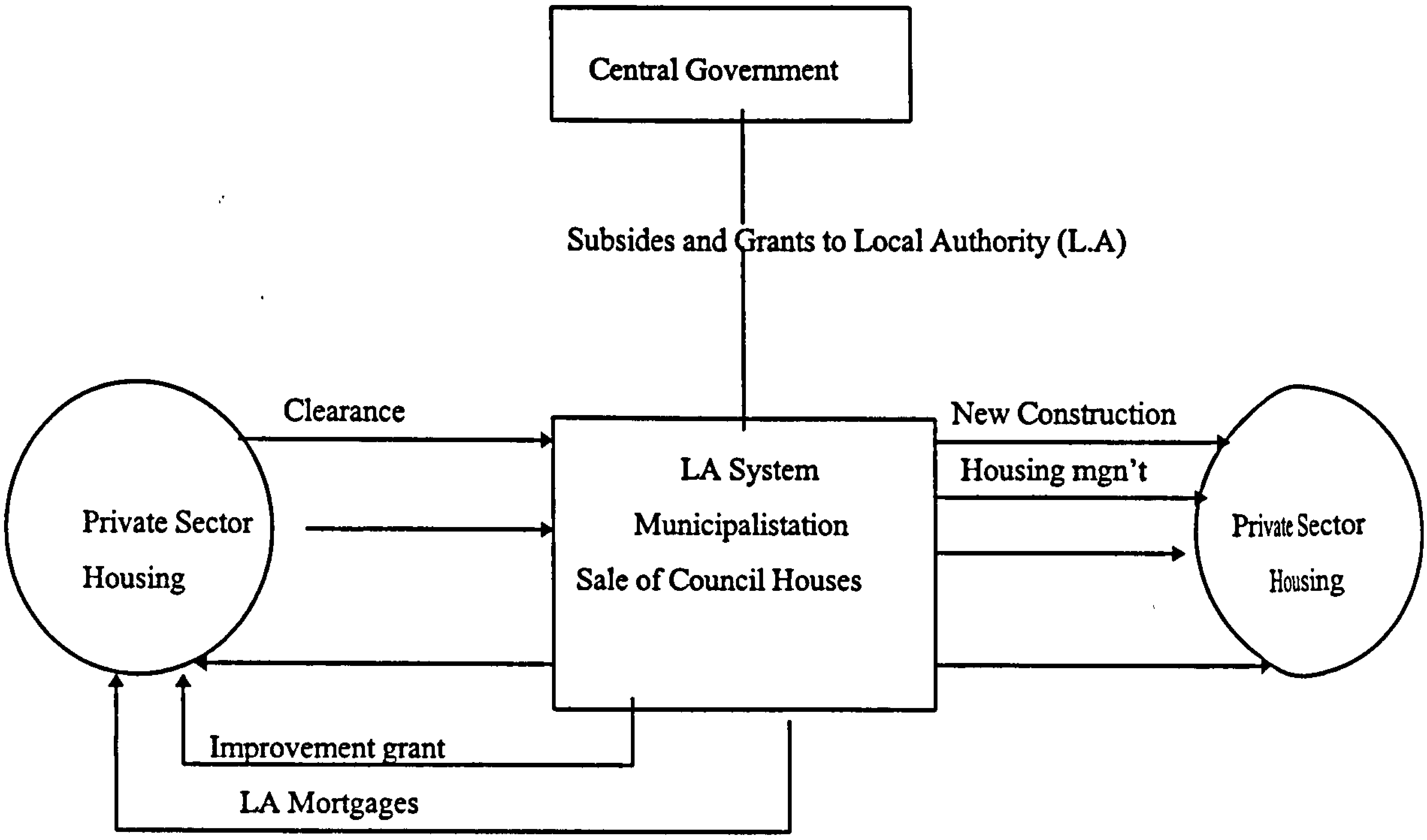


Figure 3.1: Local government and housing policies

Source: Short (1982)

3.4 The Inter-war Period

The extent to which the first war precipitated changes in society and in social policy was far reaching. Headey (1978) has described World War I as a watershed in British housing history. It was argued that the intense and great sacrifices from the whole population as a result of the war demanded reciprocal commitment on the part of government to major social reforms which became an unwritten social contract (Titmuss, 1958). The emotive electoral propaganda towards the end of the war in 1918 in relation to housing provision was the need to provide 'houses fit for heroes'. Following from the social reform policy which resulted from this noble and ambitious phrase, the idea that central government finance should be used to subsidise local authority building became acceptable for the reconstruction process.

It was reported by M.C.C. (1947) that prior to the first world war, the Manchester municipality had never really embarked upon a large scale programme of new building.

Through the agency of the Health Committee, municipalities mainly strove to improve appalling sanitary condition of existing houses.

The extreme shortage of houses for the first World War heroes led to the formation in 1920 of a Housing Special Committee for the implementation of the Housing Act of 1919, in order to bring the Act to full effect. The Act, commonly referred to as the 'Addision' Act set out to introduce the necessary drive to overcome housing shortage by means of a generous subsidy from the central government. The implementation of the objectives of the Act exerted strenuous demands upon available limited resources. Most prominent was the shortage of bricklayers which called for special measures which had significant impact upon construction methods for the period. The shortage demanded that an alternative to brick had to be found to supplement brick as wall materials for house building (M.C.C, 1986).

This problem posed a dominant handicap to the successful implementation of the house building programme set by the Committee. This resulted in unimaginable delay and frustration that even at the end of the second year of the four year plan, there were only 546 completed houses out of the original plan of 20,017 houses. Whilst progress during the first two years was appalling and discouraging, the Committee justifiably felt that much valuable ground work had been performed. Effective steps had been put in place which led to the formation of an independent department which was to take responsibility for the control and supervision of every phase of house building. At the end of the plan period, only 3900 houses were completed.

The apparent failure of the 1919 Act was attributed to the attempt by the central government to exercise too close a control over the local authorities, which led to the passing of the 1923 Housing Act. Whilst the 1923 Act permitted local authorities to continue to build upon the opportunities offered by the preceding Act, it primarily sought to offer opportunity for private builders to build houses for owner occupation. The emerging social classification problem of the time festered upon this Act, in that it catered for the middle class family at the expense of the needs of the equally deserving cases of those unable to provide necessary capital to make up the difference between available mortgage and purchase price for houses. The early recognition of this problem led to a passing of the 1924 Housing Act. In all, the 1923 Act produced 1,352 houses for letting as shown in Table 3.2, through the Manchester Corporation and gave capital subsidies to enable 5,037 owner occupied houses to be built.

Table 3.2: New houses achieved by the 1923 Act

Estate	No. of Houses	A2	A3	B3
Burnage	620	36	382	202
Newton Heath	134	-	116	18
Wilbraham Road	598	76	422	100
	1352	112	920	320

Source: M.C.C. (1947)

In the same manner as its predecessor, the Housing Act of 1924 was intended to secure an entirely different set of conditions from its predecessor. Its main objective being to secure houses to be let to the working classes at affordable rents. In this Act, the central government was seen to play both roles of enabler and enhancer of house building. This it achieved through the introduction of a scheme of skilled manpower development in the building industry to sustain the continuous implementation of the provisions of the Act over 15 year period, and an incentive plan entrenched in the Act in order to increase the speed of house production for local authorities to give consideration to alternative methods of construction to include a fair wage clause for building trades apprentices.

The overall object of this Act was most ambitious and much more farsighted in comparison with all its predecessors. A magnificent total of 16,277 out of a total of 27,447 houses was achieved under the 1924 Act. It was during the tenure of this Act that Manchester housing conquest grew in leaps and bounds as articulated by the (M.C.C. 1947).

'Prior to this Act, wistful eyes have been cast at the constituted authorities of Manchester's neighbouring districts, but it was during the tenure of this Act that the municipality began to actively overspill to neighbouring districts. The most prominent being the Wythenshawe estate, with 4,797 houses built under the Act'.

By 1930, it was estimated that Manchester still had 70,000 unfit dwellings out of its total housing stock of 180,000 (private and council). The Housing Act of 1930 was the first comprehensive attempt to deal with the problem of slum. Under the Act, measures were taken to abolish slum area, to recondition unfit houses which were in no short supply in the inner areas of Manchester. Under the Act, only a modest 15,000 houses were earmarked for clearance by the city council in a five year programme (Burnett, 1986). The tardiness was most probably due to huge capital costs involved in the provision of new dwellings at such a pace in keeping with the amount of demolition over a relatively short period of time.

The 1930 Act made a number of provisions:

- (a) in the declaration of clearance areas
- (b) the setting up of improvement areas and,
- (c) in dealing with individual unfit houses.

The Act thus heralded, in the most effective and legitimate manner, the process of demolishing the old and erecting the new to the joy of many public health reformers.

3.5 Importance of Housing legislation

The review of the various Acts are helpful in fixing the history of housing endeavours over time. The Acts constitute the charter under which local authorities could legitimately pursue their housing work.

Through out this period, Manchester was described (Dale, 1980) as an authority with severe housing problems of an old industrial city with added complexities of residential succession which are typical of metropolitan cities. The result was that the restriction of government policy was always more problematic than authorities whose problems were more straightforwardly those of physical obsolescence.

3.6 The effect of the second World War

At the out break of the war in 1939, it was generally believed that housing demand and supply were in some state of equilibrium (Headey, 1978). By 1945, at the end of the war, some 3.5 million dwellings were estimated to have been damaged to some degree, whilst at the same time six years of stagnation on the construction front had been suffered.

In Manchester alone, over a thousand dwellings had been destroyed or so badly damaged that they were beyond repair (M.C.C., 1986) without accounting for thousands more dwellings which had suffered less serious damage but nevertheless requiring repair works to be carried out.

The Labour government elected in 1945 recognised the severity of the resulting housing shortages and took some bold steps at combating the problem in a spirit reminiscent of 1919. Whilst the first few years after the war were concentrated on repairing bomb-damaged housing, the government rigorously pursued the policy of construction rather than one of improvement.

One of the pragmatic steps taken by the government was the tackling of the problem of land shortage. During the inter-war period, land purchases had relied on philanthropic large landowners, this trend was totally reversed by the impact of town planning legislation from 1947. Compulsory purchase made the acquisition of building land much easier for local authorities (Fletcher, 1990). The result was that by 1957 a total of 2.5 million new houses and flats had been built, 75 per cent of which was by local authorities. The government, between 1965-69 inclusive produced approximately 1.8 million houses with a peak in 1968, almost equally divided between the public and private sectors. Given this level of success in government housing pursuit and the immediate post-war housing shortage had been met, an increasing important place was given to slum clearance and the improvement of unfit dwellings (Burnett, 1978).

3.7 The Right-to-Buy Act of 1980

The most radical measure to denigrate local authority housing was the Housing Act of 1980 which provided the right for secure local authority tenants to buy their home at substantial discounts from the market price, with automatic right to a local authority mortgage if required. In order to gain a full appreciation of the impact of this policy upon overall local authority housing, it is useful to examine the sales figures along side housing construction for 1979 to 1989. Table 3.1 shows that sales exceeded new building by local authorities from 1980 onwards reaching the lowest levels since the introduction of subsidies in 1919.

Table 3.1: L.A. dwellings completed and sold in the UK 1979-1989

Year	Dwellings completed	Sales of local authorities dwellings
1979	75,573	42,285
1980	76,997	85,840
1981	54,889	112,061
1982	33,205	215,797
1983	32,805	157,382
1984	31,593	118,454
1985	26,125	106,268
1986	21,277	101,068
1987	18,671	122,319
1988	18,828	176,518
1989	15,107	

3.8 Theory of housing zoning

Residential location theory

The pattern of urban land uses in industrialised countries is often explained by the concept of concentric zone model (Garner, 1970). This is especially relevant to the problem of housing maintenance in any city as the pattern of evolution of housing bears heavily upon the spread of deterioration in residential properties. Whilst the research does not seek to test the hypothesis of the relationships between social class and maintenance requirements, a conceptual understanding of how housing evolution is informed by social classification would constitute a firm bedrock for a better appreciation of the problems which are being studied.

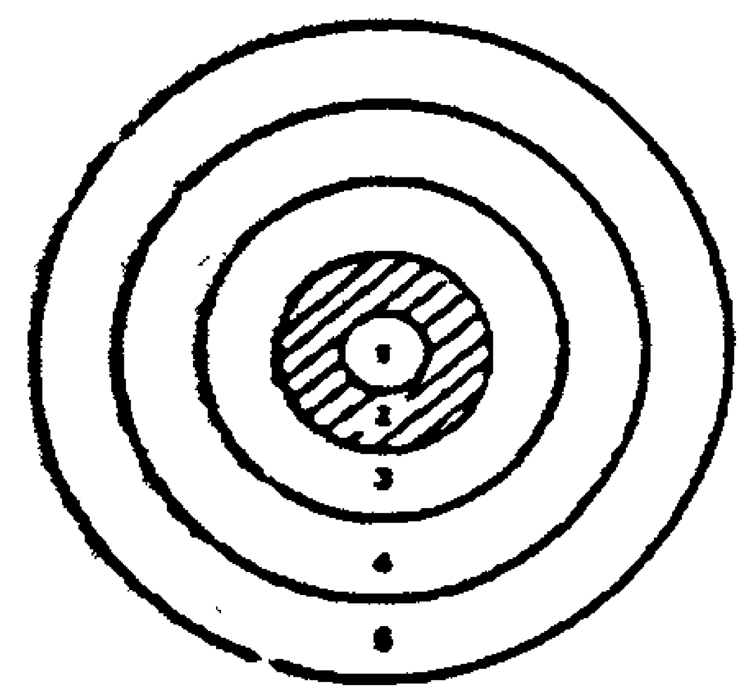
Based upon Burgess's (1925) studies of Chicago, Baldwin (1979) developed a conceptual zoning of housing in modern cities (see Figure 3.2).

At the epicentre of the concentric boundaries is the inner zone which is principally the central business district (CBD) forming the nucleus of the city's commercial, cultural and social life as well as being the focus of urban transport. Immediately surrounding this is the urban zone being the main area of dilapidated housing, which also includes light manufacturing, wholesaling and other businesses. This area has been described by Balchin (1979) as the 'twilight area' because of its blightful conditions of much of this zone.

Surrounding the urban zone is the low class residential zone which according to Balchin's (1979) interpretation of Burgess's observation, is "inhabited by the workers of industries who have escaped from the area of deterioration but who desire to live within easy access of their work". The low class zone is in turn surrounded by what is described as middle and high income housing zone. Surrounding this is an outer zone beyond city boundaries, 'a commuter belt of suburban and satellite settlements'.

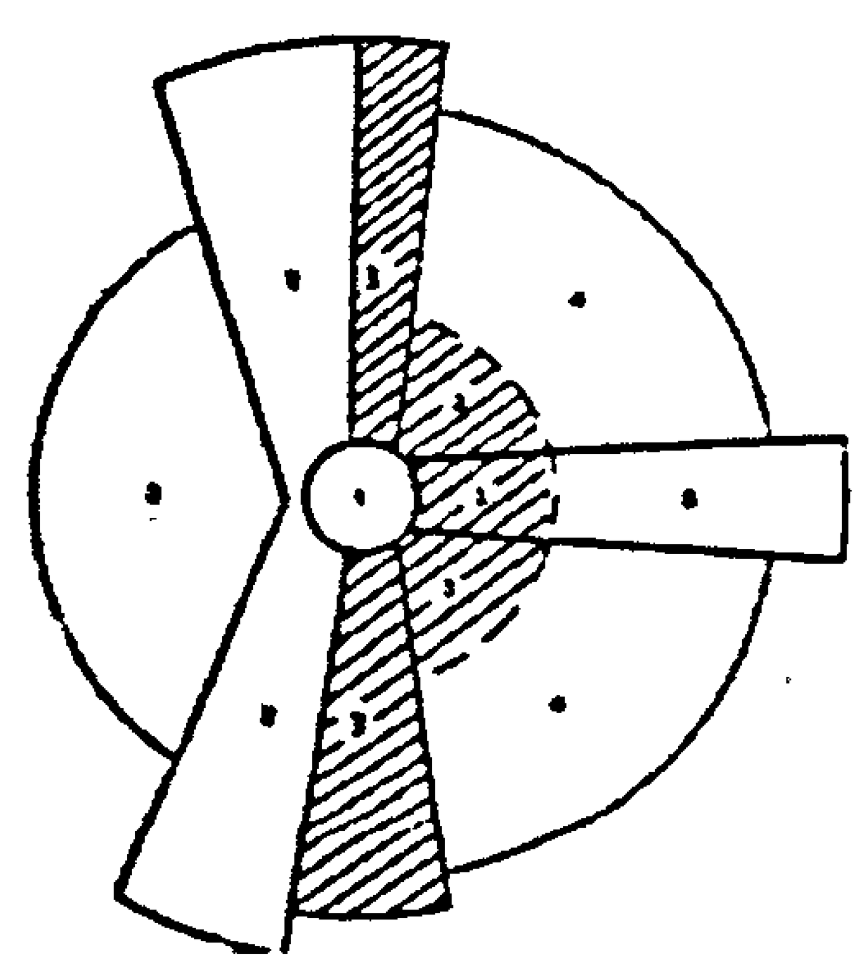
Whilst the evolution of every city tends to follow this pattern, in actuality, departure from such regimented concentric zones is inevitable in practice, and hence, the acknowledgement that no urban area is a true fit of the ideal scheme.

THE CONCENTRIC ZONE MODEL



1	CBD
2	WHOLESALE LIGHT MANUFACTURING AND LOW-CLASS RESIDENTIAL
3	MEDIUM-CLASS RESIDENTIAL
4	HIGH-CLASS RESIDENTIAL
5	COMMUTERS ZONE
▨	MAIN AREA OF DILAPIDATED HOUSING

SECTOR MODEL OF URBAN STRUCTURE



1	CBD
2	WHOLESALE LIGHT MANUFACTURE
3	LOW-CLASS RESIDENTIAL
4	MEDIUM-CLASS RESIDENTIAL
5	HIGH-CLASS RESIDENTIAL

Figure 3.2: Conceptual model of zoning of housing in modern cities

Source: (Balchin, 1979)

In a real world, urban growth is influenced by three forces of nature namely; centripetal forces of attraction, centrifugal forces of dispersion, and the forces of spatial differentiation (Balchin, 1979) rather than by one homogeneous force which enable urbanity to be fitted into a spatial mould as in the idealised 'concentric model'. The consequence of this multiple combinations of physical forces is a radial routeway patterning of urban land uses. The result is that the pattern of urban settlements may sometime be highly fuzzy around the urban zone, low class residential zone and the middle and high income housing zone. Whilst the suburban and satellite zone tend to retain its purity much more than the rest of the zones.

It is intriguing that neither of the two operational areas (North and South) of Manchester from which the sample population was obtained falls into either the epicentre or the satellite zone of Balchin's (1979) models. In other words, the population sample dwellings are of moderate urbanity spread without the feature of extreme zone characteristics.

3.9 Tenure

The tenure by which a household occupies its accommodation is an important characteristic of that household. It has been described by Ball (1986) as the way households pay for housing, and their relationship to its ownership. Farthing (1974) emphasised the importance of the tenure of a household on legal and financial responsibilities and rights of the tenants.

In reality, the basis on which individuals occupy their dwelling includes a large number of individual circumstances. In the UK, tenures are believed to be associated with different social images (Forest and Murie, 1988). The dominant image of owner-occupation often reflects and reinforces social differentiation along tenure lines. Whilst tenure categorisation can be listless and inexhaustive, it is common to condense these categories into four main tenure categories in the UK (Farthing, 1974). These are, owner-occupation, local authority renting, private renting, and housing association renting. Figure 3.1 shows the housing tenure in GB between 1969 - 1989

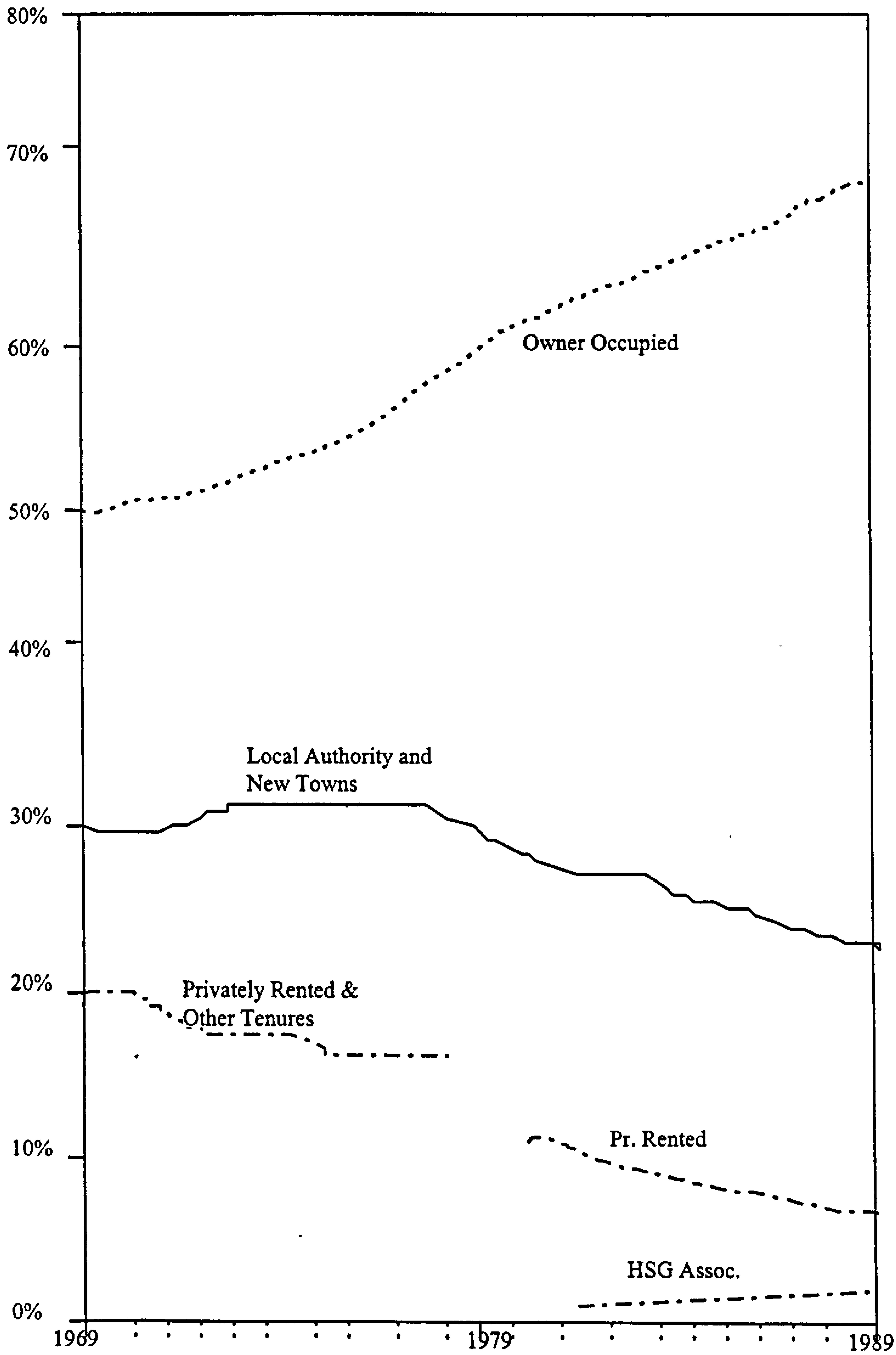


Figure 3.3: Housing tenure in Great Britain 1969-89
Source: Housing and Construction Statistics, HMSO (Malpass, 1993)

According to Malpass (1993), before the First World War, about 90% of housing was privately rented, with 10% being owner-occupied. Local authority provision at this time was negligible. Since then, there has been a steady decline in private renting, accompanied by a corresponding steady increase in owner occupation, and until 1979, in local authority renting. Judging from Table 3.2 and Figure 3.3, the sale of public sector dwellings from local authorities, government departments and housing associations was the major source of growth in the owner-occupied sector in the post 1979 era. By 1979, local authority housing reached its peak in its proportion of national housing provision at about 32% of total national stock. Since then local authority housing provision has suffered a steady fall as shown in Figure 3.3.

One important feature of housing tenure is increasing social polarisation. Because owner-occupation has been embraced by a large segment of society, it has become increasingly socially diverse, whilst local authority housing has experienced a growing concentration of the least well-off. Reporting on the Family Expenditure Survey data of 1953-4 (Gray, 1979) claimed that only 16% of families in the bottom quarter of the income distribution were local authority tenants, but has grown to 43% in 1976. According to Malpass (1993) more recent data confirms this trend. In 1988, two-thirds of council tenants had weekly incomes of less than £150, compared with 18% of owners.

3.10 Summary

This chapter has reviewed the history of public housing, and discussed the significant part played by the various Housing Acts mostly of the 20th century as precipitator for the present public housing condition. The effect of the Housing Act of 1980 as the most radical measure by the government to denigrate local authority housing is notable, with sales attaining an all-time high of 215,797 in 1982 in contrast to just 33,205 being completed.

The theory of housing tenure and land uses was set in perspective as a means to understanding the evolution of cities and pattern of tenure, of which the city of our interest is no exception. The relationship of the theoretical residential location zoning to the survey population from the two operational areas (North and South of Manchester City Council) was defined as of moderate urbanity spread. Essentially, any differences in maintenance characteristics between dwellings from any part of the city could not be explained as resulting from housing tenure and zoning differential. The link between tenure and social differentiation in the UK was discussed. Exponents are generally agreed on the fact that council housing tenants fall into the lowest income brackets of the population.

CHAPTER 4
DEFINITION PROBLEMS IN BUILDING MAINTENANCE

4.1 Introduction

The study has as its main objective, the identification of major factors which determine or strongly influence maintenance need and then establishing the interaction, if any between these factors. It is therefore pertinent to the study to clearly establish the bounds of maintenance in order to be able to achieve the research objective.

The existing problem of lack of distinctions in maintenance activities is a major constraint to the proposed study, which if not solved will distort any eventual findings.

In order to avoid this it has been found crucial to adopt a contextual definition of maintenance and its scope. It is believed that this initial critique will ameliorate several of the problems which could arise later on in the study.

There are few housing strategies which have been more widely and consistently advocated than the maintenance of existing properties. This trend is being fostered by the developing trends in nations' strict economic measures to conserve scarce funds and depleting resources. The trend tends to support making less funds available for new development or even substantial reconstruction activities on existing properties.

Despite this, perhaps because of its commonplace day to day application, housing maintenance has only very recently become the subject of much systematic, nation-wide research. While there are a considerable number of studies (Drinkwater, 1967; Stoaling, 1985; Allen, 1986; Kelly, 1988 and Griffin, 1990), many are confined to industrial boundaries (Drinkwater, 1967 and Kelly, 1988), whilst those intended to address construction and property are ad hoc and sometimes too highly specialised (Stoaling, 1985; Allen, 1986; and Griffin, 1990).

There is little consensus concerning maintenance definition and even more confusion concerning its different levels and interpretation. 'Repairs' versus 'servicing' versus 'replacement' versus 'improvement' versus 'rehabilitation' etc. These definitional ambiguities reflect the character of building maintenance in that it can be many things and can assume a wide range of guises. Amidst the present confusion, there may eventually be a black-out of historical sense of maintenance, except the current trend is reversed. It would appear that this gloomy prospect and the overwhelming confusion surrounding terminologies in the field of maintenance prompted Mole (1992) to suggest that building maintenance will do well to be re-named.

To improve this situation, this chapter seeks to present a collection of meanings and definitions in order to achieve a justifiable industry wide definition for the term.

4.2 Review of general definition

The Oxford dictionary defines maintenance as "being maintained, keeping in repair........to maintain is to cause to continue........to preserve in good order". Many definitions have been proffered including those by Tucker & Rahilly (1990) and Pitt (1987). These definitions are only tangential to the above definition.

The definition identifies the range of characteristics to be imparted to a property by any one action of maintenance. Thus, the main aim of maintenance can be succinctly put as providing serviceability to the building, hence, the need to highlight those attributes of maintenance which contribute to building service.

The BS3811 (1984) definition of maintenance has become paradigmatic. It defines maintenance as a "combination of any actions carried out to retain an item in, or restore it to an acceptable condition". It should be kept in perspective that this definition does not have any particular product or industry in focus, but is of general application.

Two processes are envisaged in the definition; namely preventive and corrective maintenance. As illustrated in Figure 4.1, maintenance action is determined by a set acceptable level of deterioration. This action comes either as preventive as in servicing of components or as corrective in the form of repairs, partial improvement or replacement.

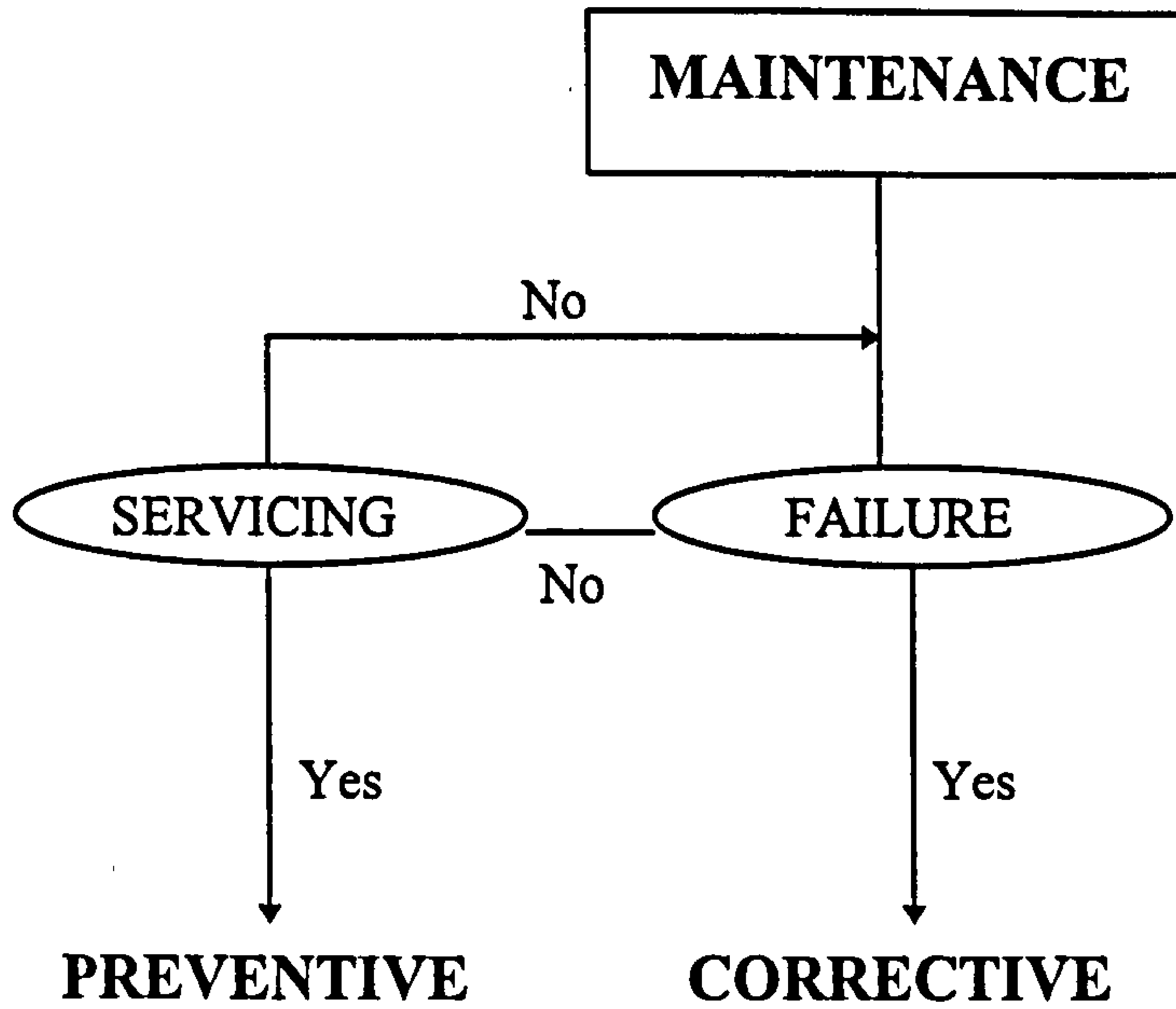


Figure 4.1: The two main types of maintenance as used in the industry

The concept of acceptable standard is also brought into sharp focus. Standards are set by comparing the physical condition and amenities of a building with some arbitrarily set fitness criteria (Lee 1987), usually rooted in public health legislation with little regard to occupiers' preferences and social acceptability. A standard is a dynamic phenomenon and multi-dimensional. It varies with differing groups and most potently with time.

The variability of standard with time and the need to retain the property in an acceptable condition call for an element of improvement as a necessary integral of maintenance. In buttressing the view, Lee (1987) argued that the standard acceptable at the time of undertaking the work may be higher or lower than the initial design standards. More often than not, the standard deemed acceptable would be higher than was originally provided and any work of maintenance should incorporate an element of improvement if it is to fulfil its anticipated function in a satisfactory way. This notion is parallel with the recommendation of the HMSO (1972) which requires that maintenance action should seek to keep, restore or improve every part of a building, its services and surrounds, to a currently acceptable standard, and to sustain the utility and value of the facility. It would then appear that the category of improvement action that will fall within the bounds of this latter recommendation must be such as primarily seeks to keep the 'status quo'.

That is to say, any improvement action that is superfluous in the light of current standards and the initial status of the building cannot be considered as falling within the bounds of the BS3811 definition. This stance corroborates Whites *et al's* (1969) opinion that maintenance is synonymous with controlling the condition of a building so that its pattern lies within "specified regions".

Figures 4.2 and 4.3 illustrate the interactions between the various possible estate activities. There often do occur some overlapping between the different actions. The identification of such common boundaries may prove problematic. The problem may only be overcome by knowledgeable compromise in definition.

The term, 'specified regions' connotes that the status in which the building should be retained or brought to, rather than being a determinate condition, is a continuum. This region then becomes a reference condition upon which an improvement action will be judged to be appropriately a maintenance action.

A note of caution is vital at this juncture. For an improvement action to be considered within the ramification of maintenance, such an action should not, of necessity, be on a building whose standard and attributes have so lagged behind currently acceptable standards as to qualify it for a rehabilitation or modernisation exercise.

4.3 The usage of terminologies

The terms maintenance and repair are almost always used as twin words (Taylor, 1987; Seeley 1987; and Lee 1987). The joint usage of both terms has evidently grown out of simple idiosyncrasy among authors. In actual sense, repair is nothing but a component or subset of maintenance action. The current academic idiosyncrasy can however be misleading, and it does in fact show the extent and seriousness of conflicts yet to be resolved in the field of maintenance. An action carried out on a building may not of necessity be a repair action and it is however not understandable why most authors are inclined to using both terms in conjunction, when in actual sense, the one is but a component of the other. This general inclination may have arisen out of a general misconstruction of general repairs being all that maintenance is.

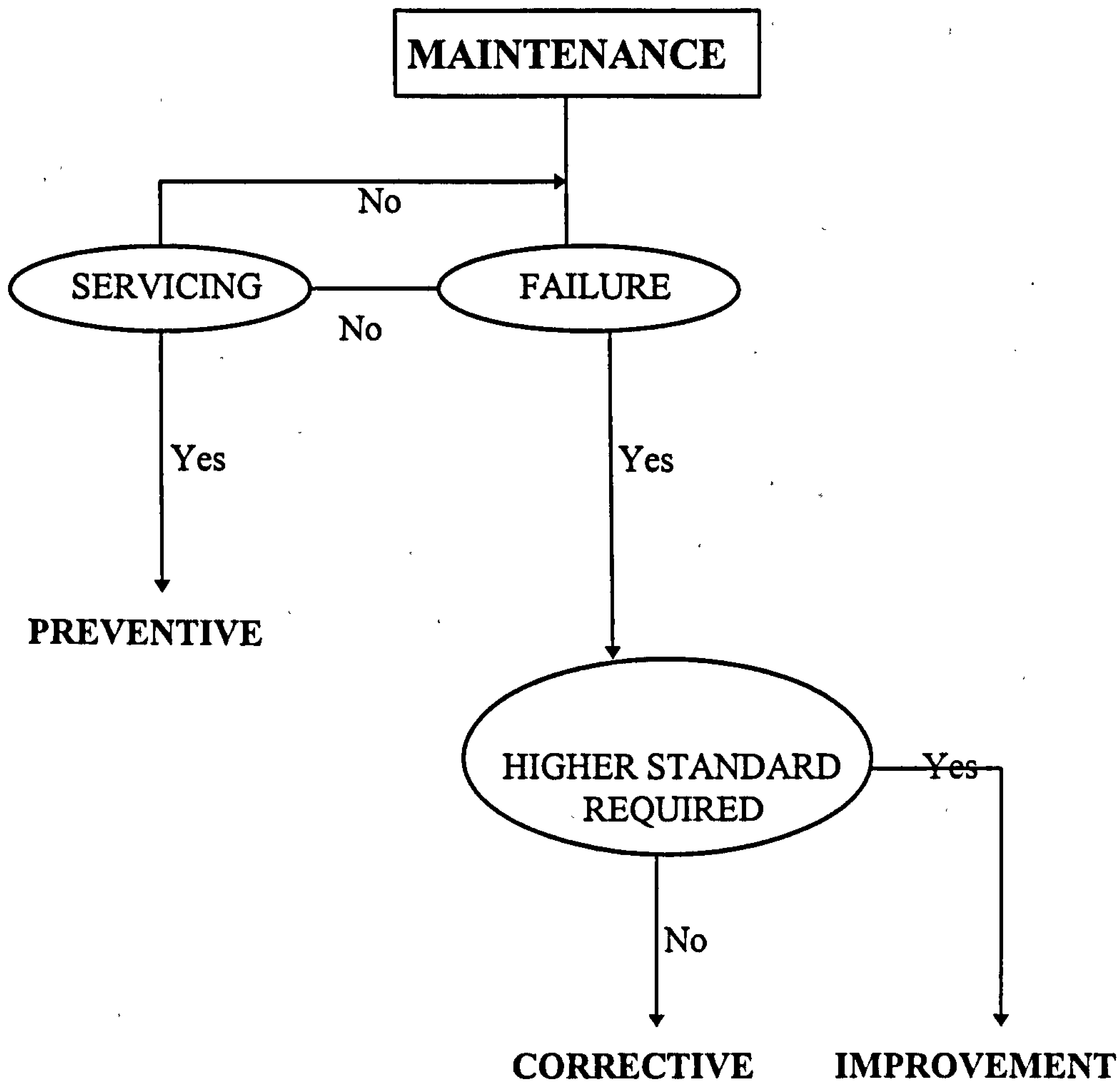


Figure 4.2: Typification of maintenance options

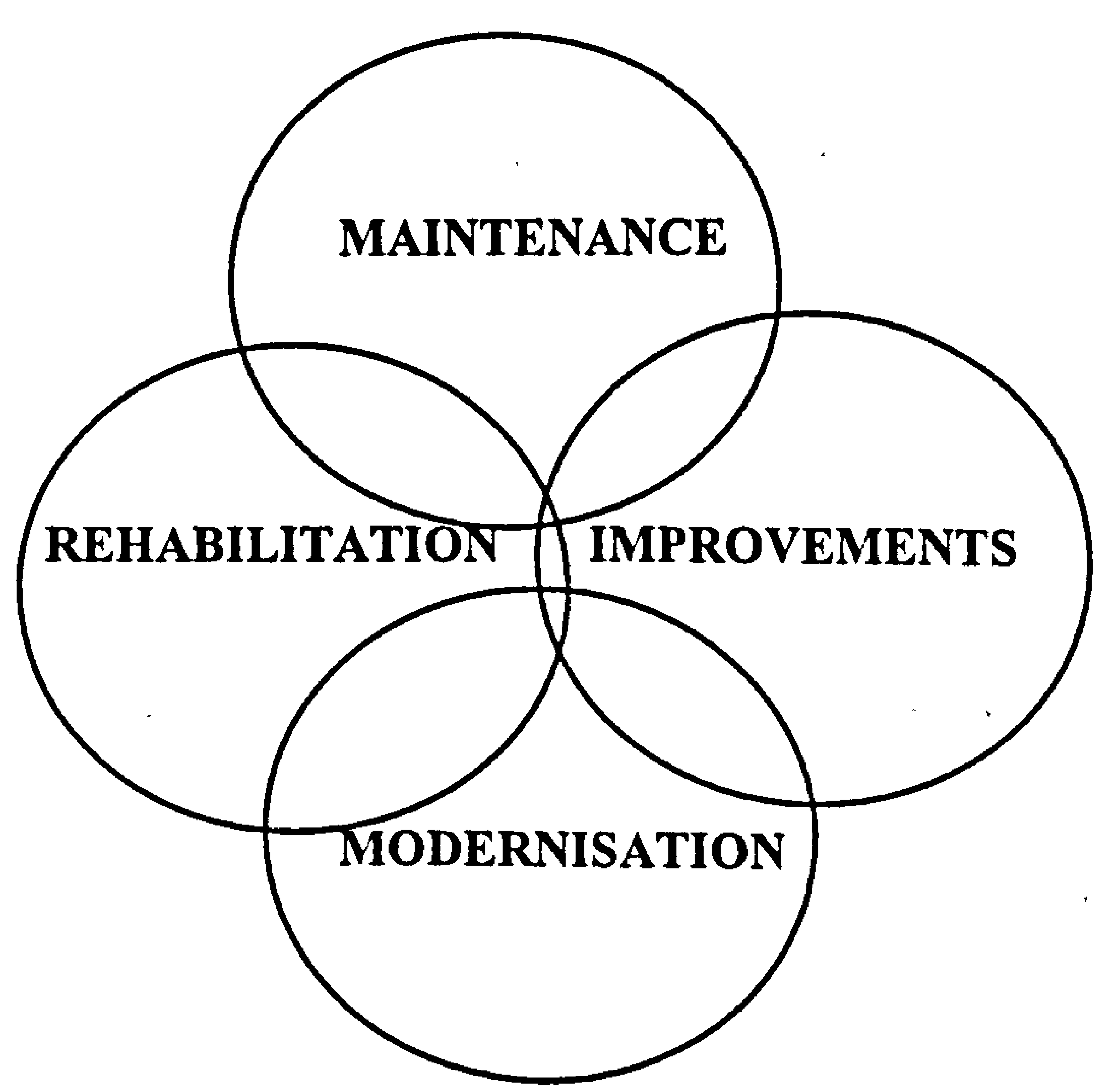


Figure 4.3: Work classification on existing building portfolio

It is possible to infer that the joint usage of the terms means that the two processes act in unison to fulfil one and the same purpose. In other words, each is a process which constitutes an end in itself. Neither of the two suppositions is tenable in the light of earlier contention that maintenance is a combination of several processes. Melville and Gordon (1981) commented that the neglect of maintenance is what gives rise to many of the repairs which do arise in buildings. The usage of maintenance in this context has been limited to mean nothing more than non-technical house keeping, and does imply that repair is a separate function from maintenance. In other words, the joint usage of the terminologies is in respect of distinct processes which relate on a 'cause and effect' basis, and having the same end result of 'keeping the building in good condition at all times'. The fallacy of this opinion is obvious, and may have been precipitated by the wrong usage of terms in the sector.

With virtually no exceptions, authors use the two terms either interchangeably or jointly without any rule of thumb guiding the usage.

For the purpose of this study, the existing position is considered misleading. It is contended that whilst repair work is a maintenance action in its own right, maintenance is far more than repairing. In fact, maintenance is an umbrella term encompassing repair.

4.4 A cursory look at semantics

In technical texts and journals treating the subject of maintenance and related construction works upon existing building portfolios, the following terminologies are to be encountered, namely: modernisation, rehabilitation, renewal, refurbishment, alteration, extension, improvement, repair and replacement. A lot of confusion exists in the usage of these terminologies.

A distinction can be developed between rehabilitation and maintenance. Whereas maintenance is most effective when a balance is struck between the two extremes of portfolio management spectrum; abysmally low along the spectrum is a condition ranging from total or near total neglect to under-maintenance. Highest up on the spectrum is the range of over-maintenance. Neither of these two extremes is cost efficient. In fact, the two conditions are two evils, the one of which is both uncertain and calamitous, whilst the other is expensive but the asset's life and utility is at least guaranteed. The unknown evil is to be held in greater derision and mostly to be avoided. If not avoided, but allowed to persist for any length of time, it results in abject state of disrepair. In this condition, no ordinary act of maintenance will serve to bring the building back to a satisfactory functional state. It is at this stage that maintenance overhauling is required which is adequately termed rehabilitation. Rehabilitation displays the general characteristics of maintenance operation, but much wider in scope and spanning the entire building fabric, whereas normal maintenance action may involve only a few building elements at any one time.

Refurbishment is often associated with the upgrading of the general features of a facility in the form of re-decoration in order to make it more attractive in the property market. Whereas rehabilitation makes a salvage of a defect-ridden facility, refurbishment redeems it from imminent incursion of defects.

Dixon (1990) described modernisation as being concerned with alteration and enhancement to buildings on both a small or large scale. This stance is rather pedantic, thus portraying modernisation as the umbrella which houses other major estate actions. In its pure sense modernisation is nothing more than an adaptation of a facility to meet present day needs and demands in the services provided by a building without having to redevelop. It explores the relevance of a functionally obsolete property in meeting new demands often occasioned by technological development. It would seem that improvement is a minutiae of modernisation in the sense that the former is usually widely spread throughout the building. In other words, modernisation is an amplified improvement work on a building.

Figure 4.4 defines the work content classification for the various estate activities identified so far.

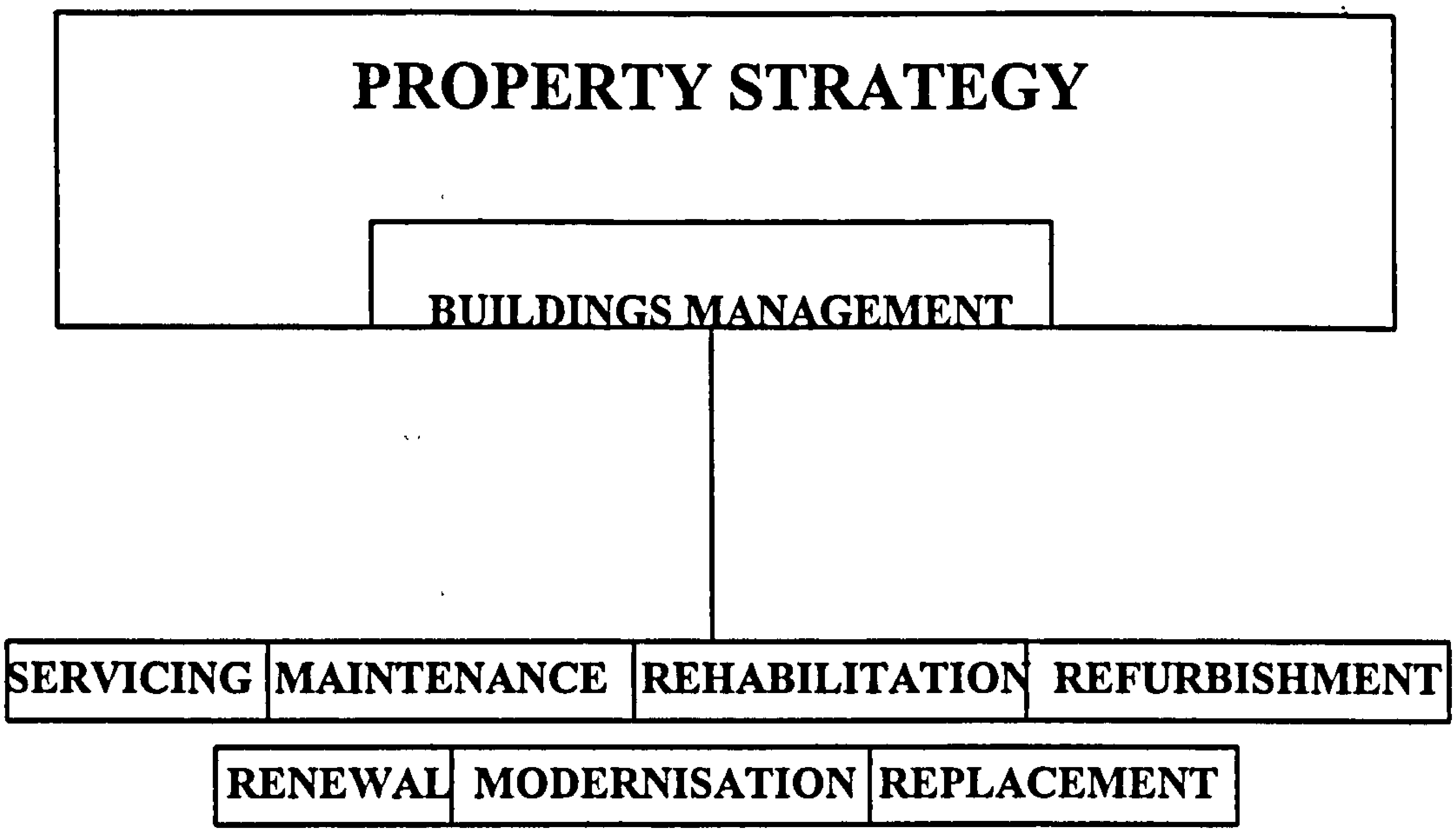


Figure 4.4: Work content classification on existing buildings

Renewal has been described as an estate activity which often encompasses all the others but with significant actions in the form of new work to the property. It does however fall short of redevelopment in that it retains the general features of the original building whilst making substantial additions and/or alterations to it in order to enhance its functionality.

4.5 Summary of definitions

Arguably, construction suffers from the effect of uncertainty more than most other human undertakings. This problem is most acute in the specialised field of construction maintenance where reliable cost prediction is made difficult or impossible by poor quality historical data or even an entire absence of it. This has led to the conclusion (Holmes, 1987) that in many cases the available data is of very little value in the assessment of maintenance. The problem throughout the maintenance field is the lack of suitable data to sensibly discuss performance and cost over time. In the light of this problem, it is crucial to develop a model of cost prediction which places little reliance upon existing poor historical records. In seeking to achieve this the following constraint has been established.

Maintenance is a generally semantically confused area of construction, with it assuming various meanings with individuals with differing backgrounds and idiosyncrasies. The foregoing section has addressed this constraint and raises such issues as are relevant to the development of a clarity of thought on the subject. The conceptual definition of maintenance adopted in this research is figuratively demonstrated in Figure 4.3.

4.6 Maintenance Characteristics

Apart from work due to 'change of tenancy' and 'Prior to Painting' repairs all other repair work is based on demand (Holmes, 1985). This observation is a valid one but it does not support any generalisation as he did, that maintenance need or requirements are tenants' own origination by way of reporting. This will only be the case if maintenance is purely construed to mean day to day items of work to the exclusion of programmed repairs. To posit a limiting definition of this sort will not be doing justice to a global understanding of the general phenomenon, although by so positing, an otherwise intractable variable can become more manageable.

Another distorting parameter in maintenance is the fact that maintenance is often dictated by budget. Budget is controlled by certain policy decision as the financial year progresses and so costs can be arbitrarily controlled to match budget. In essence, the time of the year is related to the actual maintenance done. From this observation, it can be arguably inferred that actual maintenance done is not a true index of actual maintenance need. This inference has been implied by Spedding (1987a) when he asserted that maintenance is budget led. To assess actual maintenance need, we must put ourselves in a position where we may correctly determine demand for maintenance from all sources; be it from tenants or form the housing organisation. This position is succinctly articulated in Figure 4.5.

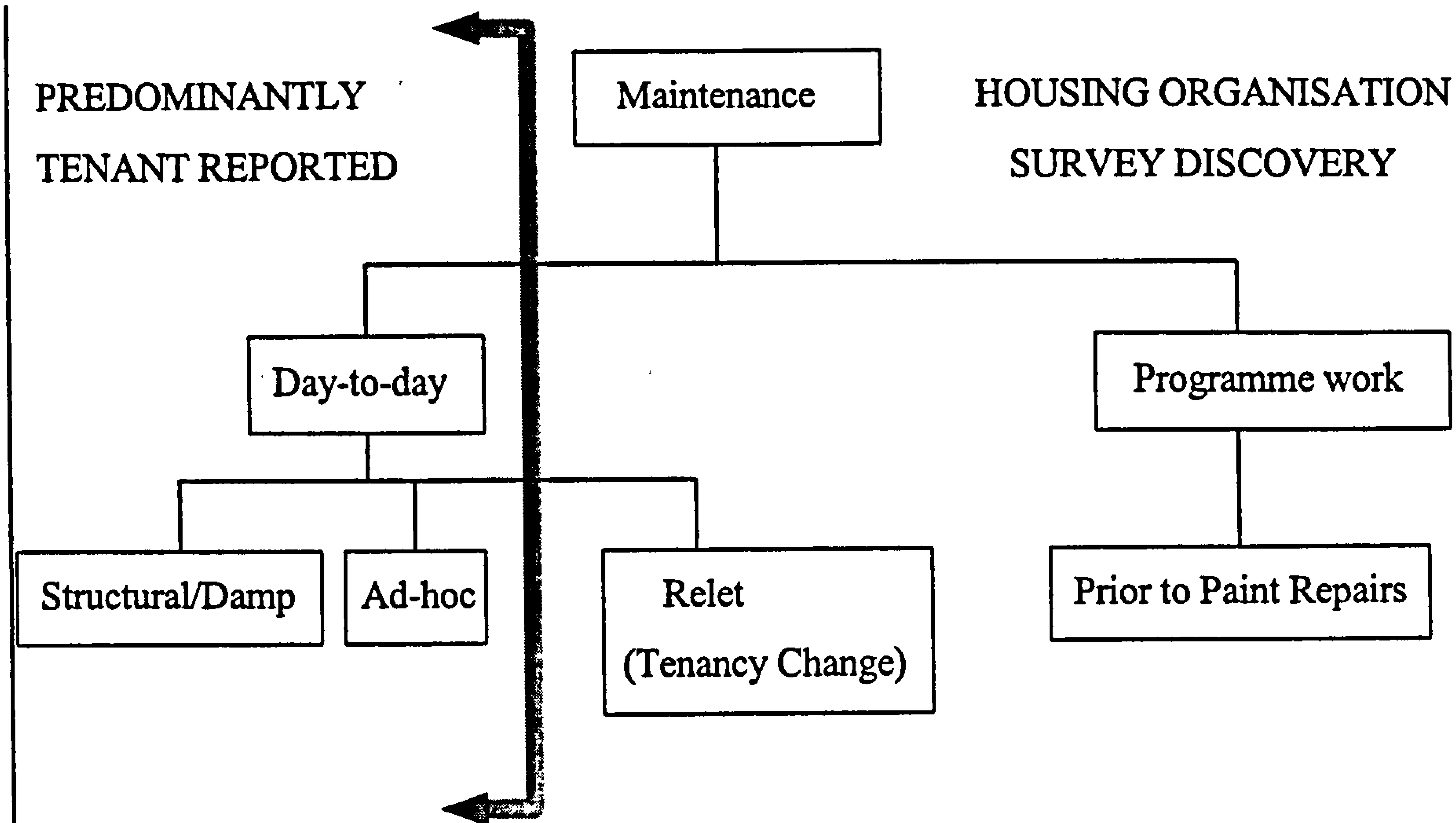


Figure 4.5: Source and classification of maintenance work items

4.7 Types of Maintenance

Maintenance work has been broadly classified into two (Clifton, 1974; BS 3811, 1984) namely; planned and unplanned maintenance as shown in Figure 4.6. These two categories or any further division of them are not completely separable and distinct (Spedding, 1987a). The conventional thinking is that the higher the proportion of planned maintenance is to unplanned maintenance the higher the level of control within the maintenance organisation. The fallacy of this reasoning very easily comes to light when it is understood that these two categories of work fall into two distinctive budget heads and that the administration of work related to the former comes as a bona fide contract. Hence there exists no objective basis for comparison of price or cost.

Spedding (1987a) concludes in his work that preventive maintenance does not relate to actual failure but to assessments of tolerable risk. The significance of this conclusion is that preventive maintenance is not an indication of sole maintenance need, but of an admixture of actual and probabilistic maintenance need dictated by financial priority of the time.

Quah (1991) has underscored the general nonchalance of building owners which is evident by the limiting of upkeep to the very short term on one hand, and on the other hand to a discrimination of cyclical work to such works as re-painting, re-roofing and routine servicing of equipment. Maintenance of the remaining elements is most commonly left to reactive measures on receipt of complaint. It is almost not practicable to include more items of cyclical work, as historical records of programmed work are seldom available and where it is available, hardly ever accurate and complete (Holmes, 1985; Bromilow, 1987; Bird, 1987). In this light, if it was possible for one to decipher items of reactive maintenance from the body of maintenance work carried out by an organisation and given the actual set of requests from which the reaction was subjectively or otherwise extracted, one would be close to a safe approximation of the body of maintenance requirement (for further discussion see chapters two and eight on methodology and measurement of maintenance requirement indices respectively). Figure 4.6 illustrates this point.

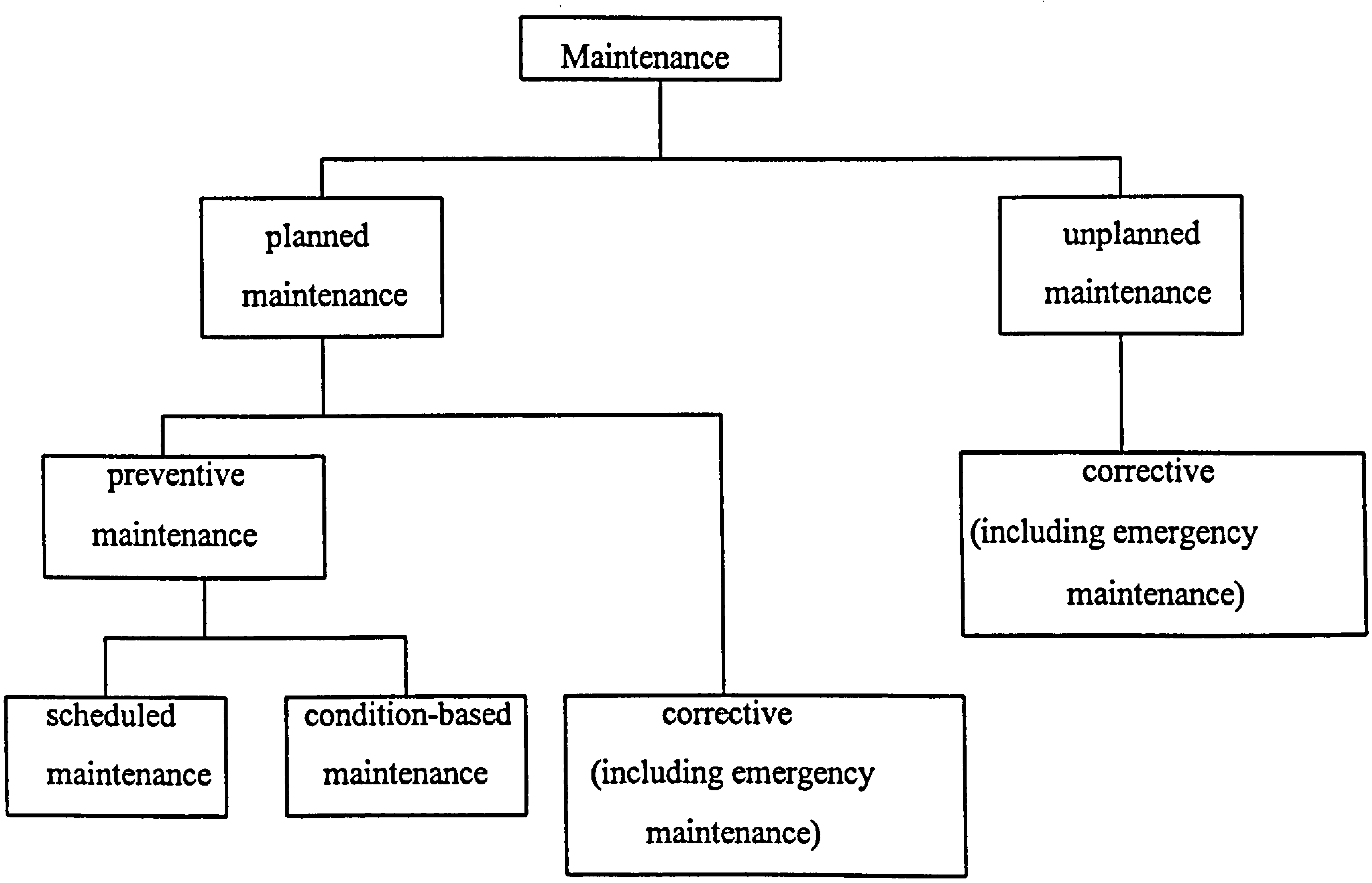


Figure 4.6: Maintenance classification

4.8 Maintenance expenditure

Property owners all too frequently endeavour to keep expenditure to a minimum, without due considerations being given to the long term consequences of such an action or policy (Hollis and Gibson, 1991). Whilst to an investor, the main criteria for further investment by way of expenditure on the building is the net income plus the net capital appreciation that can be expected in anyone period, this is not strictly the case with housing and particularly with local authority housing as it runs its stock more or less as a social service. The main objective for investment is to enhance the life span of the stock and to fulfil its legal obligation to the tenants.

Wide variations exist in expenditures on housing stock owned by different landlords, be it private or public. This results from varied attitudes to maintenance; whereas some prefer to barely maintain the building, others choose to maintain at optimum level. This allows cost differentials to exist (Brown and Robertson, 1990).

There are three phases of cost in anyone occurrence of maintenance item. This compounds the problem of comprehensive understanding of the behaviour of expenditure patterns. These stages as identified by Stone (1980) and Pitt (1987) are:

1. The direct cost incurred by the maintenance organisation in the form of labour, materials with or without percentage overheads depending on which of the two options of contracting and direct labour method of work execution is employed.
2. The actual price paid for work by the owner of the building; which is (1) above plus the mark-up element of the contractor.
3. The direct loss suffered by the occupier of the building resulting from loss of output or additional expenses to ensure the same level of output resulting from the disturbance.

Another major factor which distorts maintenance cost information is the frequent occurrence of emergency repairs which divert funds away from routine maintenance programmes and are so very often priced disproportionately to the actual cost incurred.

As at 1976 the percentage spent on maintenance in terms of capital value of the Local Authority stock was 0.96 per cent and in the private sector was 0.91 per cent (National Income Statistics, 1976). Between the ten year period from 1976 to 1986, Robertson (1988) reported that increase in maintenance spending in the private sector has been more significant than in the public sector.

The general view is still that in relation to the capital value of stock maintenance costs are globally low. It has been argued that the extent of maintenance work done is a compromise between need and the ability or willingness to pay for it (Baker, 1976). The HMSO (1976) referring to the whole area of maintenance costs commented as follows:

"very little is known about future maintenance requirement and .... past expenditure levels are an inadequate guide to future requirement."

This admission has serious implications for the housing stock management system and leaves little or no room for manoeuvre in the management of housing maintenance expenditure as it lacks any reliable history to live upon. There has been a long standing history of high variability in maintenance expenditure and standard in both the public and private sectors. This, according to Wyatt (1980) is largely controlled by:

1. owner occupier's decision on whether to invest in his dwelling and maintain a high standard of facilities or to do the minimum or nothing for reasons ranging from ignorance to lack of fund;
2. affordability of landlords taking into account any legal requirement controlling standards and financial returns; and
3. availability of financial resources represented by the level of income from the Housing Revenue Account in L.A. housing authorities.

This renders cross-sectional maintenance expenditure data unamenable to analysis in order to identify major parameters in maintenance need and performance. A way forward in order to overcome this obstacle may be to focus upon the actual stock rather than a pre-emptive phenomenon of the stock as its expenditure pattern. Most of the maintenance items are not defects in the sense that we have now come to associate them with premature failures.

A useful rhetoric that needs to be addressed in respect of efficient management of building stock is "what will I need to spend on this building, year by year, during its foreseeable life......" (Bromilow, 1987). He went on to identify the issues to be addressed in relation to maintenance expenditure as;

1) the most appropriate timing for maintenance operations to be done; and
2) the amount to be spent if buildings are to be kept at a given standard of performance without significant backlogs being generated.

To fulfil these needs, there must needs be sufficient knowledge regarding the determinants and mechanics of deterioration.

4.9 Expenditure forecasting approach

Three approaches for maintenance expenditure forecasting have been documented (Bromilow, 1987). The first approach is to review the nature and incidence of maintenance and other operations from past records of work done to each building as a basis for inference for future needs. This is basically the approach employed by Holmes (1985) and Fletcher (1989) in their studies on maintenance cost characteristics. The limitation of this approach is that cost histories are poorly documented, not only in terms of actual figures but also in terms of work content and therefore unreliable.

The second approach generates future maintenance expenditure from a percentage figure of the real capital value of building stock. The actual percentage adopted is based upon such information as is available. The National Association of College and University Business Officers (NACUBO) in the U.S.A. was quoted by Bromilow (1987) to have recommended 1.33 per cent of building cost annually. Sherman and Dergis (1980) on the other hand proposed an age dependent formula that increases annually at the rate of 0.052 per cent, which is in line with the Department of Environment's proposition of 1972. This approach works upon the premise that the more expensive the market value of the stock, the more costly it is to maintain. It takes no stretch of imagination to appreciate the fallacy behind this thinking as several factors influence property market value which are not in any way related to its maintenance. It is evident that this approach is rather too naive. The BMI (1988) has criticised the use of percentage figure for future maintenance expenditure as a misleading Rule of Thumb as more often than not these figures are estimates of national or local expenditure and are inappropriate for assessing maintenance budget needs of specific properties. It underpins the problem by stressing the need to prepare budget in the light of factors affecting the building to be maintained, required standard and usage.

The third approach uses a simulated life pattern of a building using a mathematical model of the activities that should take place in order to keep the building at a pre-determined level of serviceability (Pitts, 1987; Phillips, 1986; and Bromilow, 1984). This, to every intent and purpose is a very reliable technique for projecting likely future maintenance. It, however, does not address the practical problems surrounding "the how and why" of the incidence of maintenance items, and therefore doubtful if the simulated life pattern is reliable.

An evaluation of the (GEHA) forecasting technique would bring the common shortcomings of maintenance expenditure prediction models to the fore.

4.9.1 The Government Employee Housing Authority (GEHA) - Australian experience

In the bid to improve the efficiency and effectiveness of housing stock through better management of capital and recurrent expenditure, an integrated maintenance forecasting model was developed in Australia in 1986. The model employs a combination of the first and second approaches documented by Bromilow (1987).

The objectives of the model were;

1. to provide a basis for forward planning and budget forecasts
2. to contribute to the evaluation of options of maintenance, rehabilitation, demolition/rebuild or sale of stock (Tucker, 1990).

In this model, the house as a building is divided into 19 individual components. The supposition being that each component gives rise to recognisable maintenance activities. The principal assumptions upon which the model is based are:

1. that the cost and timing of maintenance for each element can be pre-determined;
2. that costs are always dependent upon dwelling size (number of bedrooms); and
3. the application of stochastic distribution of the 'next due' dates for component failure

The problem with the approach of the model lies not only in the validity of the assumptions but also in the fact that the model does not concern itself with exogenous variables that impact upon decay and maintenance requirements. Furthermore, the assumptions are founded upon very tenuous theoretical premise.

The estimation of the 'next due' dates is dependent on the assessor's judgements. Whilst it may be possible to reduce judge's bias by some rationalisation and training, Walker's (1989) experience shows that it nevertheless remains an unproved statistical method.

Because the model appropriately recognises that it is the exception rather than the rule for maintenance to be done on schedule, Tucker employed a stochastic simulation construct to perfect the model. The construct simulates a group of houses, and that maintenance falls far short of the correct level. It presupposes that (a) only 20 per cent of items are done between 90 per cent and 100 per cent of the scheduled time, and (b) the remainder are completed by 190 per cent of the scheduled replacement time following a beta distribution rather than a normal distribution.

So vital as the simulation construct is to the final model, there is no firm basis for its usage in this instánce. It is at best based upon hunch rather than scientific appropriateness.
Serious as this set-back may be, it would nevertheless not warrant that the model is completely useless, were it possible to develop a fit for the model. In the absence of a fit, given this serious aspersion, the reliability of any model should be called to serious question.

4.10 The theory of Satisfaction among tenants

Satisfaction has been described as a user-response attitude to the comfort, convenience and fulfilment offered by the built form (Birks and Southan, 1992).

A large number of variables are believed to influence the level of satisfaction expressed by residents of the built form (Bulbridge and Smith, 1973). Most importantly, this depends to some extent on two points (Crosby, 1985). One is the density of housing scheme in relation to the dwelling that is, whether high, medium or low rise and the other is the housing management approach and responsiveness in relation to the various dwelling forms and densities. Important as these influences may be, it is an over-simplification of the nuances of satisfaction, which in itself is as complicated a subject as understanding human behaviour. Satisfaction is an individual attitude which is influenced by both intrinsic as well as extrinsic parameters. Essentially, the design of built forms is an expression of anticipated interaction between the consumer of the built form and the wider environment. Newman (1972) argued that built forms have traditionally held the role of social control of socially undesirable behaviours. In a symbiotic environment as this, we may safely suppose that to the extent that housing design plays a role in the control of deviant behaviours among residents, to the same extent would deviant anti-social behaviour result from an inefficient design.

A more pragmatic view of built environment was posited by Perin (1970) when he suggested that a useful way of looking at built form is in terms of the changes (or neglect) people wish to make to it to suit their behaviour, rather than how the built form determines behaviour. These changes may be both positive (expressed by careful attention to the fitness and up-keep of the dwelling) and negative (expressed in neglect and even avoidable or wilful damage by residents).

He opined that "social relationships are always a concomitant of spatial arrangements and physical elements is hardly a fact to be received with surprise. The quality of social relationship however, is so much more a function of non-spatial and non-physical variables that research in environmental design to predict quality is misguided". In confirmation of this view, Crosby (1985) argued that environmental effects on individuals and social structures depends on previously formed personality trait. He concluded that it is erroneous to apply territoriality concepts in the hope that they will easily mould individual or group behaviour.

This theory assumes a reasonable degree of residential mobility, which in itself is frequently used as stress and tenants' satisfaction indicators for urban and sub urban areas with social and physical problems. Valid as Crosby's (1985) theory may appear to be, his argument is based upon the premise that residents are necessarily 'imported' to the environment. The scenario will not be the same where individuals are bred from within the context of the built environment. Hence, the character formed in offspring who may never have to move away from that environment will, of necessity, be a product of the design.

In a study of medium and high rise dwellings (Stevenson *et al*, 1967) found that high density gives rise to social problems in housing estates as a result of children coming together into groups, and invariably impacts upon the general satisfaction of tenants in such estates. Its real problem in such instances is not so much with the children groupings as with the vulnerability of the estate as a result of such groupings to infiltration from outsiders. Social science research into the relationship between behaviour and physical environment has tended to diversify, with a penchant for unification around the assumption that the quality of human relationships cannot be directly related to territorial considerations. In a study of a private housing scheme in London, as reported by Crosby (1985) it was found that in higher density schemes, children's play was a major source of conflict and difficulty (Shankland, Cox & Associates, 1971). Whilst some people see the open space as a place for children to play on, others as something to gratify the sight.

Wherever conflicts such as this is inherent in the built form, satisfaction is dampened. The effect of which may, by and large, be reflected on the immediate dwellings occupied by individual residents. The loss in the level of satisfaction is often accompanied by the desire to move and possible neglect by the resident.

Studies into tenants' satisfaction are commonly agreed in their findings that dwellings with the least satisfied tenants tend to be in poorer state of repairs than those with more satisfied tenants (Burbridge and Smith, 1973; Shankland, 1971; and Stevenson et al, 1967).

4.10.1 Satisfaction among tenants

Tenants' satisfaction with the condition of a building is believed to depend on three points:

- The density of dwellings in the neighbourhood (that is to say, whether high, medium or low rise),
- The allocation policies followed by the local authority in relation to the various built forms and densities (Burbridge and Smith, 1973) and,
- The responsiveness of the landlord to repair problems (MCC, undated)

Satisfaction for housing tenants can mean any one or a combination of the following (Birks and Southan,1992);

1. increased loyalty to the housing department and organisation
2. encouragment to prospective tenants to patronise the same organisation
3. many complaints over trivial matters
4. failure to look after the dwelling or surrounding
5. rent avoidance.

From the above list of satisfaction indicators, it is clear that an assessment of the satisfaction expressed by a tenant is a useful pointer to the level of care the tenant gives to the physical dwelling which he/she inhabits. The age old proverb 'action speaks louder than voice' finds expression loud and clear. This position is at variance with the theory that satisfaction is inexpressible as suggested by Birks and Southan (1992).

Birks and Southan (1992) have suggested that three factors should be considered in measuring satisfaction among housing tenants. These are;

1. Validity: This has been described by Rowntree (1987) as the extent to which the test measures what it is intended to measure, and is supposed to measure.

2. Reliability: This is described by Reece and Walker (1994) as the extent to which it consistently measures what it is supposed to measure. It is believed that a perfectly reliable test will give identical results in all conditions.
3. Actionability of the results: This is an assessment of the efficiency with which the test can be administered.

The robustness of any measurement test is often threatened by the approach adopted for the development of the survey instrument.

According to Birks and Southan (1992) one of the simplest and most consistent means of measurement of satisfaction in terms of its administration is the bipolar scale. Simple and consistent as this may be, the problem lies in the objectivity of the measure and what satisfaction means to the individual.

In this study, we have tried to measure the level of satisfaction expressed by the tenant in relation to the quality of repairs carried out by the local authority as perceived by the tenant, albeit, from a layman's point of view across the entire building fabric. This approach corrects for the relatively simpler approach adopted by the Department of Environment in the Housing Appraisal kit, which according to Furbey and Goodchild (1986) lacks the required ingredient for validity and reliability although, apparently efficient.

If the DoE approach was adopted in this study, a less rigorous and obviously more respondent friendly question as 'How satisfied do you feel about repairs carried out by the council?' would have been used to develop a satisfaction index. As in Question No. 3 of Appendix 1C, this type of question was actually asked in a validatory capacity rather than as the chief instrument for the construct.

Overall, the satisfaction construct in the study measures two of the identified criteria by Birks and Southan, namely; complaints over trivial matters and how well the dwelling and its surrounding environment is looked after.

Three key features of emerging paradigms of satisfaction have been identified by Birks and Southan (1992):

_ satisfaction is dynamic;

_ satisfaction occurs in a social context; and

_ satisfaction can be both conceivable and expressed.

4.11 Property Condition

The need to determine the weight of this maintenance criterion is underpinned by the fact that no two dwellings are necessarily precisely at the same level and standard of maintenance.

As would be expected, the traditional approach to determining the condition of the property is to conduct a condition survey. The problems with condition survey is well documented in the next chapter. Apart from the intractable problem of subjectivity among surveyors, the employment of this method was made impracticable because of the limitation of fund and time for the research, and the inauspiciousness of a second round of visit to the subjects within the sample survey.

Confronted with these problems, it was decided to determine certain external components in a property that most strongly indicate the general condition of the property in terms of maintenance. The reason for this is to facilitate the conduct of condition survey on the sample dwellings by merely conducting an external view without having to knock on doors, thus avoiding the likely event of not being granted entrance or of not meeting the tenant at home and the suspicion of incessant calls.

4.12 Summary

Chapter Four sets out, in part, to elucidate upon what constitutes maintenance having firstly identified the confusion among authors on the various grades of work to existing buildings. One of the major requirements in dealing with maintenance is to specify what the terms mean. A conceptual meaning of maintenance that formed the basis for the study is figuratively illustrated in the Figure 4.3. It illustrates that what is considered to be maintenance action could be a moderate combination of the different grades of work namely; rehabilitation, improvement and modernisation with what is customarily referred to as repair action.

The chapter proceeded to review the theory of tenant's satisfaction in order to justify this element as an important aspect of maintenance need. This was based upon the studies of Burbridge and Smith (1973), Shankland (1971), and Stevenson *et al* (1967) which commonly found that dwellings with the least satisfied tenants tend to be in poorer state of repairs than those with more satisfied tenants. In this chapter a strategy for the measurement of satisfaction expressed by tenant in relation to quality of repairs is devised.

CHAPTER 5

FACTORS IN MAINTENANCE REQUIREMENT PROFILE - A REVIEW OF LITERATURE

5.1 Introduction

Maintenance expenditure by local authorities on housing properties is constantly being squeezed up by central government as less and less funding is allocated to local governments year in year out. The situation is further compounded by the government privatisation programme which is being extended to social housing management sector. This places every housing manager under serious pressure to cut costs without cutting service, in order to survive imminent competitions.

The panacea for survival and improved competitiveness (effectiveness, economy and efficiency) according to Mole and Olubodun (1995b) lies, in part, on the reduction of maintenance expenditure. In order to achieve the desired cost reduction, there is a dire need to possess a comprehensive understanding of how those costs are generated in terms of factors which influence defect generation. Doing so will enable a pro-active strategy whereby these causes are redressed at every stage in the life of the built-form.

5.2 Existing approaches to factorial studies in maintenance

In seeking to improve effectiveness, maintenance managers typically place their greatest emphasis on the management of financial resources to control the standard of the physical asset (Hodgkinson, 1990). Underlying this, is the implicit assumption that the greatest opportunities for increasing effectiveness lie in this direction. Most maintenance considerations, (Spedding, 1990; Ngo, 1990; Flanagan et al, 1987) have placed much emphasis on budget - maintenance interaction rather than the actual mechanics for two major reasons;

1. To execute financial control in line with maintenance expenditure budget.

2. To satisfy the needs for accountability.

An earlier study by Holmes and Droop (1982) stated that " maintenance is budget oriented rather than needs oriented". This led Ashworth and Au-Yeung (1987) to deduce that maintenance events will be carried out when and where the needs for maintenance and the adequacy in the provision of maintenance funds co-exist. Although this state of the art is yet to be empirically verified, there has not been reason to believe the contrary. There has therefore been more emphasis on the magnitude of maintenance cost figures than the causes which give rise to maintenance needs to the detriment of the development of a systematic maintenance framework. It has been said that "the practical implication of built asset management must be judged on its ability to secure adequate funding " (Then, 1990).

It has become an incontrovertible general notion therefore, that budget is a major maintenance function parameter, but caution may have to be exercised to avoid the wrong impression that the relationship between the two variables excludes the interplay of other strongly influential factors. The issue is that some considerations give rise to budget, and budget leads to the accomplishment of desired objectives. A synchronisation of these tripod issues of consideration, budget, and objectives in the context of maintenance is desirable. A balance in the assessment of the " cause and effect " phenomenon of all the parameters involved is the most reliable safeguard to prudent maintenance management. Some of these parameters have been identified by Ashworth and Au-Yeung (1987) namely: physical characteristics, performance characteristics, environmental characteristics, human characteristics, time characteristics and user characteristics.

The existing imbalance in these factors is the major cause of distortion to historic maintenance cost data and planning. Thus merely representing at its best, affordable fund by client organisation without any semblance of actual maintenance requirements.

Whereas, Ashworth and Au-Yeung (1987) identified these maintenance cost characteristics, and schematically demonstrated the inter-relationship between them, it goes without saying that relationships are not simply established by shear “links and lines” without necessary substantiation with analytical information on how each characteristic affects overall maintenance cost performance and how they all interact. Their work seems therefore to be based upon the assumption of expected relationships.

Barlow and Proschan (1965) demonstrated in a mathematical manner how the time characteristics influence maintenance cost forecast and sought to determine the optimum replacement time which minimises the expected cost under specified conditions. Two major flaws are evident in their work. The proposition treats the time aspect of maintenance function in isolation, thereby making it as suspect as the existing paradigm which isolates the budget factor in maintenance, and over emphasises it. Besides, it would appear that the model has no place for any other maintenance option otherwise than replacement whether or not such options offer more optimum choices. In the face of this, an optimum forecast solution cannot be attained.

Nakagawa and Osaki (1982) have attempted to overcome the latter situation by introducing some flexibility into their models which proposes a repair limit replacement policy. This stipulates that a failed component be repaired if the repair time is short and replaced if the repair time is long. This is expected to be achieved by stopping a repair if it is not completed within specified time and the item is then replaced. The fact that this model is based on trial and error calls for caution in any application of it. Since the first may end up being abortive does make the approach less than optimal. A more efficient approach must seek to pre-determine the time required for the repair to assess whether or not it is short enough. On the other hand, Drinkwater and Hastings (1967) considered a similar replacement problem for army vehicles, and then proposed that a component requiring repair is first inspected and repair cost estimated. If the estimated cost exceeds a certain amount then the unit is not repaired but is replaced. This certain amount remains to be determined.

In another unrelated work, Ngo *et al* (1990) found physical and environmental (location) characteristics to be significant factors in maintenance forecast, and went further to claim the existence of correlation between the two factors. Whatever that correlation is, they are silent about it. Though, it will appear from the work presented that the observation is assumed rather than arrived at. It is nonetheless useful as it transcends the myopic approach of isolating a factor without any consideration of the existence of dynamic relationships with other factors.

Based upon data drawn from confidential BRE maintenance cost returns, Whyatt (1980) alluded to the fact that some dwelling construction forms cost more to maintain than others. This point corroborates HMSO (1976) view that non-traditional blocks of flats built in the immediate post war period are known to cost more in annual maintenance than traditional types of dwellings built at the same time. He further opined that maintenance requirements are influenced by the actions and expectations of tenants in the public sector. He claimed this to be particularly true on unpopular estates where vandalism is rampant and where occupancy turnover is high and councils are required to redecorate. So much as this observation appears valid, he limits the dwellers' influence only to the impact of what they are and not to who they are. He also, as would be expected, subscribed to the age-long notion that "the older the dwelling becomes the more the financial resource need requirements".

The influence of age of building on maintenance has been well researched and almost over-flogged (Alner and Fellow, 1990; Holmes, 1985) to mention only a few.

In his work Holmes (1985) suggested that there are variable relationships between maintenance expenditure and age and therefore forewarned of the risk of lack of reliability in its use as an index for forward planning in maintenance. Alner and Fellow (1990) also generalised a relationship between the age of school buildings and cost of maintaining them, and found this relationship to vary with construction method.

The factorial consideration of age in maintenance requirement is a necessity imposed by the simple fact that some phenomena (both positive and negative) generate or degenerate deterioration. As in the physical sciences, time is but a fundamental concept out of which theory and observation is built (Hage and Foley, 1988). One of the basic laws of physics, the second law of Thermodynamics says that physical systems tend to greater disorder over time and that a physical system cannot remain in the same state it was in previously without expenditure of additional energy. In the same vein, the maintenance requirement of a building is bound to increase with time if left unattended, but in that case, it is not time that causes disorder, rather , the forces which cause the disorder are exercebated by time. To therefore focus primarily upon time (age) as a causative factor in maintenance is an awkward way to understanding the actual characteristics of maintenance and its interacting influences.

5.3 Introduction to the factors

There are many factors which determine the condition of housing stock. One of the two most comprehensive list of factors so far provided was by Honstede (1990), though his list was anything but specific. The factors which he identified were;

- the quality of the constructional components of the housing at the time it is completed;
- technical aspects of the ageing process;
- the effect of maintenance and home improvement on the quality of the housing; and
- the manner in which occupants make their housing.

Whereas Honstede's (1990) factors emanated from a purely sociological appreciation of the problem of housing quality, Gambardella and Moroni's (1990) study demonstrates a more technical appreciation of the same problem. In their study of building pathology Gambardella and Moroni (1990) identified three sets of factors which they believe influence maintenance condition and its subsequent cost as follows:

1. A set of 'internal parameters' that is to say, parameters that pertain to the building object and determine its capability to provide individual performances. Within this set, design, construction and interdependencies of the elements were identified. Thus suggesting that maintenance should be related to design and construction not just on life cycle costing basis, but upon the basis of technology and practicality.
2. A system of usage and environmental conditions which cause a series of stress actions on the building. The sub-system of tenants' characteristics and environmental stress actions are associated with this system.
3. A set of previous maintenance actions.

In their work, Spedding *et al* (1995) considered four groups of factors in the development of the W.P.E. System Ltd priority category matrix method namely;

- physical condition
- property status
- user effect; and

- fabric effect.

Their multi-attribute approach for prioritising maintenance was apparently based upon nearly holistic but non-specific factorial considerations.

In the main, the works by Honstede's (1990) and Gambardella and Moroni (1990) appear to identify virtually the same set of factors at play in building maintenance need profile whereas that of Spedding *et al* (1995) built on the former by making practical application of the factors identified.

5.4 Vandalism

Vandalism has been described as wilful damage to property or to public amenities, and always with a motivation by an intention to do damage (Burbridge, 1973). Klama (1988) defined vandalism as individual behaviour directed towards causing damage to properties. As with the two exponents, there is a general consensus among exponents as to what constitutes vandalism.

Contrary to common belief, vandalism is not made up of senseless and random acts, but often calculated intention as a form of expression of dissatisfaction to the authority or society at large. Vandalism is meaningful in the sense that it gives status to the vandal. It is rooted in an attitude of lack of belonging whether or not the vandal possesses the benefit of usage. Trying to understand its psychology, Schieffelin (1973) reports as follows:

> 'A man whose expectation have been frustrated or who has suffered a wrong or injury at the hands of others does not usually surpress his annoyance. Rather, he is likely to orchestrate his anger into a splendid frightening rage projecting himself with threats and recriminations against his opponent'.

Building Research Station Digest (1971) pointed out that some of the factors which promote this feeling of frustration that vents itself in vandalistic acts are boredom and lack of discipline among young people, and unsettled conditions of occupancy, which they, by instinct, believe is the making of the society at large.

Following from these views, a feature of vandalism is that it is functional. To establish whether behaviour is directed towards causing damage to properties, or not, we must understand the root of that behaviour. Behaviour whose function is to cause damage to properties, but which fails to achieve this aim, is nonetheless vandalistic; whereas behaviour whose function is not to cause damage but which happens to do so by accident, is anything but vandalistic. Whilst all exponents agree that vandalism is expressive, it is hardly ever recognised that it could also be passive as observed in wilful neglect of affordable responsibility on a property.

Burbridge (1973) observed that certain aspects of vandalism relates to location as they are rarely randomly distributed. They tend to be concentrated in particular places or on particular types of properties and invariably influence the social rating of pockets of areas where they are concentrated . In the Netherlands several studies have been dedicated to the making of an inventory of bad functioning housing projects and estates (Kempen and Musterd, 1991). It has been pointed out that the importance of the local situation and history in understanding neighbourhood change should not be overlooked. It is posited that whether the area is in a growing or declining part of the city is essential to what happens to a neighbourhood. In his study, Burbridge (1973) opined that certain aspects of design can facilitate or discourage the activities of the vandal, although, as expressed by Kempen and Musterd (1991) associations between design and vandalism should only be cautiously inferred. Burbridge (1973) went on to suggest that an atmosphere of dereliction and neglect evokes misuse if not wilful destruction by some users, while good maintenance are respected and cherished. Evidence from DoE's surveys shows some increase in complaints about vandalism on high density design, higher rise and larger housing schemes (Burbridge and Smith, 1973). Smith (1990) claimed that the design of homes and the immediate environment can have a big effect on people's behaviour, and Coleman (1985) drew attention to the significance of design on the problems affecting housing estates.

The foregoing leaves us with an enlightened conjecture that vandalism is a surrogate to design factor and other social phenomenon.

Vacancy and turnover rates are frequently used criteria in determining potential problem housing estates. According to Kempen and Musterd (1991) the use of these indicators has the advantage of objectivity and standardisation. Having said that, the claim can not be taken too far as incidences abound where a high turnover is associated with young and transient population rather than dissatisfaction with the neighbourhood. In regard to local authority housing, The Building Research Digest Station (1971) found that vandalism is more rampant on flatted estates than in cottage estates and in larger rather than smaller estates.

Inasmuch as vandalism is not entirely non-random, it is not altogether true to suggest that it is restricted to certain locations or district. Indeed, one is inclined to suggest that every neighbourhood or estate has its own share of vandalism to a greater or lesser extent. It would appear that this led Crosby (1985) to suggest the use of an Environmental Assessment Index in evaluating the quality of an estate or neighbourhood. An adaptation of this index was the basis of the vandalism construct used in chapter eight which is derived from Question No. 2 of the questionnaire instrument (see appendix 1C).

5.4.1 Development of the Vandalism Status Index

The Vandalism Assessment Index has been used in this thesis as an instrument to provide an indication of the extent of environmental adversity to which each property rather than neighbourhood or operational area is subjected to. It has the potential to isolate dwellings located within the same area and neighbourhood on the ground that the combined exposure of every dwelling to social and environmental hazard is always unique. Where features of the neighbourhood are common and similar, it is often the case that individual tenant's reaction will differ.

The Vandalism Assessment Index is unusual and differs markedly from most assessment scales which tend to have been developed in the realms of educational and psychological instrumentation. It seeks to assess a social concept, namely the vandalism assessment of housing units by applying an instrument which gathers observable information, mainly of a physical nature. The following were therefore selected for a Vandalism Status Index:

1. Individual subjective assessment of the problem or lack of problem posed by unwelcome noise in the neighbourhood.
2. Individual awareness of the level of car theft and breakage in the immediate neighbourhood. It could be disparagingly argued of this tool that since a high proportion of the respondents are pensioners and therefore less likely to own or plan to own a car, the awareness of this cohort of the sample may be limited. However, it is also common knowledge that pensioners are usually more aware of their neighbourhood than working members of the community who are seldom present in the area during the period of activity in the day.
3. Individual assessment of environmental stress in the immediate vicinity of dwellings by way of litters.
4. Individual assessment of environmental stress in the area by way of graffiti.
5. Individual assessment of the problem posed by the existence of empty properties, as in boarded-up houses.
6. Observable level of outright vandalism in the neighbourhood.

Based upon the response of each respondent to these six instruments, an index is developed (see chapter Eight) for each housing unit for the perceived level of exposure to vandalism. Whilst none of these six instruments is personal to the respondent, however, the perception of a respondent with regards to these extrinsic attributes largely influences his care or neglect of the dwelling.

5.5 Age

There is an overwhelming consensus among researchers that the age factor in maintenance is very strongly influential. As early as 1955 Reiners (1955) found that maintenance expenditures tend to increase with age for all age bands of dwellings studied to a greater or lesser extent. In the inference drawn from his study Holmes (1985) came up with a similar opinion. He concluded that age affects maintenance cost of dwellings but subject to policy rather than to incidence of repair or design type. This is considered to be more of a sweeping inference rather than methodically drawn. It is however most intriguing to observe that Alner and Fellows (1990), upon a more sound methodological technique came up with a similar inference as Reiners and Holmes, although in their case, they considered educational buildings as against housing. Whilst they did not detect any significant relationship between age and overall building decay process, they nevertheless found a positive relationship between age and maintenance cost.

The rationale behind the apparent similarity in the findings of these authors among others is not far fetched. It is founded upon the commonality of the flaws which characterise the data upon which such findings were based in the first place. To all of these authors, maintenance is construed in its wildest, and obviously convenient sense. And because maintenance data, as it exists in its raw form often exceeds the domain of works as a result of incidence of repair, such data are more of derivatives of policy than of incidence of failure and breakdown. Despite this academic latitude in maintenance data application Kirby (1972) made a unique, though conflicting, observation which substantially differs from the others. He found that future maintenance costs do not depend on age but on the nature of maintenance operation previously performed. By this he was establishing a link between estate work carried out on property and future maintenance requirements. The confusion in Kirby's assertion with the issue of age and maintenance cost was however reverberated when he appeared to have annulled his earlier observation by concluding that historic maintenance costs tend to increase with age.

In his analysis of the data resulting from the 1991 English House Condition Survey, O'Dell (1995) found that the condition of the fabric of a dwelling deteriorates with age. He argued further that at first, the rate of deterioration is rapid, and then slows down. In coming to this conclusion, it would appear that he came short of discounting for such variables as tenure, construction and design types. Without establishing a uniform basis in a comparative work of this sort, reliability and validity become very tenuous.

These literature go to prove that the conclusion can only be as good as the data upon which basis it was drawn. Kempen and Musterd (1991) based on Bulos and Walker's (1987) work emphasised the importance of sound methodological foundation for valid inference, when they pleaded for more scientific data gathering for housing related studies.

5.6 Design

It is incontrovertible that many, but not every aspect of design affect the level of maintenance requirements and costs. According to Wyatt (1980), long before a building begins to manifest significant decay, the characteristics for the decay process would have been inherently sewn by the designer in his selection of the design; its material specification and their quality and appropriateness to the site's exposure category and local environment, and even the choice of construction form.

Design as it relates to maintenance is a nebulous factor, as design variables open to researchers for consideration are gamut. It ranges from those variables which constitute the actual building morphology such as size (floor area and number of bedrooms), storey height, low or high rise, flatted or cottage houses, interior space organisation and shape to variables relating to the intrinsic worth or quality of the building fabric such as specifications for materials, complexity of detailings, cost yardsticks applied for design, and housing standards of the time.

An analysis of building faults by BRE (undated) as shown in Figure 5.1 indicated that over 50% of the faults were attributable to design. Whilst the methodological basis for the analysis appears spurious, it would appear that the finding is further confirmed by Seeley (1987) who, in a study on low-rise traditional housing estate found that 50% of faults were attributed to design. He went a step further by classifying design faults into 41% to site and 8% to materials.

Harrison (1982) in his study limited the causative influence on defects to design or construction when he contended that distinction must be made between fault in design or construction when ever defects arise in buildings. It appears no view of defects causation could be more short-sighted.

It is worth mentioning that most comments about relationships between design and maintenance are merely conjectural. This position is supported by Holmes (1985) when he argued that problem estates cost more to maintain, and that it is yet to be established to what extent such variations are attributable to design. In reviewing an earlier work, Attenburrow *et al* (1978) claimed that it is probable that problems on some council estates are partially attributed to their design and layout. Whereas, Baldwin (1974) was unequivocal in his assertion that physical features is relatively unimportant in influencing social behaviour. The problem with conflicting views or equivocation on the influence of design on maintenance requirements as with cost begs the nebulous nature of design, with the result that researchers often view the 'different sides of the coin' in arriving at their inference.

(Coleman, 1985) argues that the influence of design on maintenance requirements possesses a second order derivative interaction. Design first influences dwellers' behaviour for good or ill and the resultant behaviour then impacts upon maintenance. Again, this is a case of a researcher focusing too strongly on an aspect of design to the exclusion of others. The 'derivative interaction' argument fails woefully where poor details for example causes maintenance problems.

5.7 Maintenance Standard

Standards relating to residential premises are laid down in various Housing Acts and relate to : ·

1. The condition of the fabric: repair, stability, dampness, natural lighting and natural ventilation.
2. The equipment and services: sanitary fittings, hot and cold water supply, drainage, cooking facilities, artificial lighting, heating installations.
3. The internal layout: space for activities and circulation, privacy in houses in multiple occupation.
4. The quality of the surrounding environment: air pollution, noise level, open space, traffic condition.

The Housing Act, 1957 section 4 re-enacted in Housing Act 1985 section 604 laid down criteria for determining whether or not a house is unfit for human habitation (Lee, 1981). According to him, a house may be adjudged unfit as a result of the severity of one, or the combined effect of two or more, of the following:

Repair: The state of repair should not be a threat to the health of, or seriously inconvenience the occupiers without any account for the internal decorative condition. Lee argued that it is difficult to show direct causal relationship between disrepair and ill health thereby making judgement about compliance or non-compliance with this requirement one of subjectivity and social acceptability.

Stability: There should be no indication of further movement which may constitute a threat to the occupants.

Freedom from damp: Lee (1981) has arguably opined that dampness is always a consequence of lack of repair. This position is as false as it is laughable. Any attempt at explaining dampness must of necessity identify the various types of it before its cause(s) can be identified. Even when explaining for the causes of condensation, it is too sweeping to arrogate every cause of condensation to careless neglect of repair or simple housekeeping. As is not uncommon, condensation could be inherent in the design of the dwelling without being the fault of the tenant in failing to exercise care, or of the landlord in failing to repair as and when due.

Whatever the cause however, Lee's affirmation that dampness should not be extensive as to be a threat to health remains inviolate. Again, true as this position may be, what is tolerable for one may not be tolerable for the other. And it therefore very much remains a matter for individual subjective judgement on the extent of dampness that can be tolerated (Lee, 1981).

Ultimately, maintenance standards for housing can be considered:

1. a matter of individual judgement which in turn will influence the rate of defects development; and
2. in the light of what stock owners or government is prepared to afford for maintenance (Traynor, 1978).

It is apt, at this stage, to comment that maintenance standard requirements should not be confused with what Weicher (1989) describes as inadequate housing. The adequacy or otherwise of a housing unit is a measure of physical features of the housing unit in its unfailed condition, evaluated against the background of the standard of the day as enunciated by Wyatt (1980). Adequacy primarily relates to what a housing unit has or does not have, without placing focus on the condition of those features. It is the condition of the composite or individual features of the building that determines maintenance and hence its requirements.

5.8 Construction

There is an underlying association between age factor and construction factor in maintenance. The pre-World War 1 buildings, whilst substantially built of durable materials are of traditional construction. Similarly inter war buildings are also essentially of traditional construction.

The post war stock (1945 -1985) is believed to be basically traditional but with some innovations characteristic of the period. Bargh (1987) argued that the shortage of labour and materials after the war led to a lower standard of buildings and of course increased defects. He observed that since 1965 two kinds of buildings have emerged. The system lightweight structures and a recent turn to traditional building.

From the foregoing, it is highly probable that construction type employed in building exerts a surrogate influence as necessary follow-up to age and design factors. Age, not in this case a measure of time since the building has been erected, but in the sense of the custom at the time of interest. This position is only at best tentative, and therefore we can not substitute the latter two factors for the former; not at least at this stage. In fact, authors are commonly agreed on the dominant influence which construction has on maintenance requirement profile (Bargh, 1987; Holmes, 1987; MCC, 1986b; ANON, 1977).

Wyatt (1980) referring to a confidential BRE maintenance cost statistics reported the result of a detailed study of some 20000 dwellings, where it was discovered that some dwelling construction forms cost more to maintain than others. A similar point was also made by the HMSO (1976) where ' non traditional blocks of flats built in the immediate post war period are known to cost more in annual maintenance than traditional types of dwelling built at the same time.

(Anon, 1977) contended that one of the major contributors of construction defects has been the application of unrealistic cost yardsticks demanding cheap buildings which have proved very expensive and has resulted in astronomical maintenance costs.

Another feature which has been linked with high maintenance expenditure is the system built lightweight structures because of the short life materials together with poor detailing and largely inexperienced workforce at the time of construction (Bargh, 1987). The BRE (undated) analysis of faults in the construction industry categorised faults into three broad headings as shown in Figure 5.1. The limitation of the analysis is glaring, for it defies logic to think that faults, be it during defect liability period or life cycle of the building, can so easily be compartmentalised. The study shows that construction related faults account for a significant 40 per cent. Whilst the figure can justifiably be assumed to be spurious, it is nevertheless a strong indication of the important role that construction quality plays in maintenance.

Typical examples of the influence of the dwelling's construction form for future maintenance requirements have been identified as follows (Wyatt, 1980):

- the ubiquitous built up felt roof which was widely used by new town development corporations,
- tile cladding on timber frame or shiplap boarding panels,
- inferior joinery and large storey height panels,
- under floor heating systems and,
- use of sealants (to achieve a water tight joint), which have a shorter life than the materials they seal.

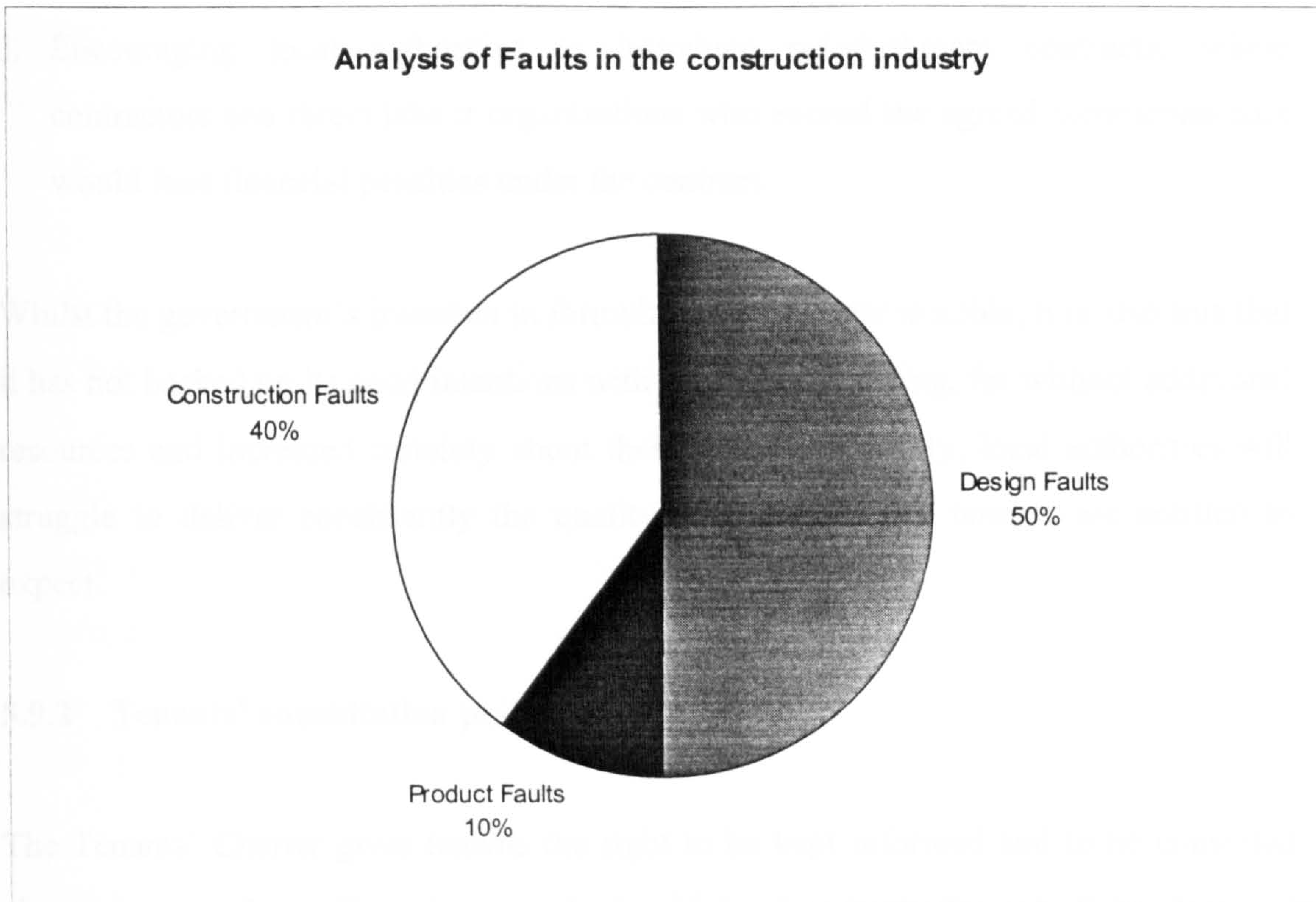


Figure 5.1: Analysis of defects in the construction industry
Source: BRE (undated)

5.9 Tenant issues

5.9.1 The Tenants' Charter

The Government's objective for the Tenants' Charter states as follows:

"those who prefer to remain as tenants, or who cannot afford ownership should be respected as the valued customers of local authorities. They have to sustain its costs. They have the right to be consulted, to expect high standards and to prompt action when performance is poor"

The Government's Citizen Charter includes proposals relevant to council tenants. Three of these refer to repairs and refurbishment (AMA, 1991):

1. Improving the rights of council tenants to the repair of their home.
2. Ensuring all tenants receive information about the standard and performance of their local authority including repair times.

3. Encouraging local authorities to introduce refurbishment contracts, where contractors and direct labour organisations who exceed the agreed completion date would face financial penalties under the contract.

Whilst the government's intention in formulating the charter is noble, it is also true that it has not backed up its good intentions with required resourcing, for without additional resources and increased certainty about their future availability, local authorities will struggle to deliver consistently the quality of service which tenants are entitled to expect.

5.9.2 Tenants' consultation policy

The Tenants' Charter gives tenants the right to be kept informed and to be consulted about matters that affect them, and should be involved, through their Tenants' Associations, in the process of deciding Council policy. There are wide ranging methods of consultation to suit different situations, from sending personal letters to tenants, to sitting on area committee meetings, speaking and voting alongside Councillors on issues that affect them.

The following methods of consultation are in use in the council on which the study is based:

Consultation with individuals
Consultation with groups
Consultation with Tenants' Associations
Consultation through project groups
Consultation through Area Housing Committees
Consultation through the Housing Advisory Committee
Consultation through a City-wide forum of all Tenants' Associations

The best way for tenants to have their say is to be in active Tenants' Association. Most, if not all housing estates already have one Tenants' Association.

Tenants' Associations are a key element to the consultation process. They are involved through Area Housing Committees and Project Groups in a formal sense, and through day-to-day discussion with area housing officers in a less formal sense.

On the formal side, Tenants' Associations can help to decide council policy. Their representatives sit on Area housing committees and project groups.

On the informal side, Tenants' Association representatives meet people from the area offices to discuss local issues and put forward their views. This enhances the development of links which enables tenants' voice to be heard.

5.9.3 Reporting of Defects

Reporting of defects is essentially about giving an eye-witness account and at the same time making limited judgement on what is observed depending on who the reporter is, thus making the whole exercise of reporting a seriously subjective exercise. According to Croome (1980) a building defect is intractably subjective unless it was brought to the notice of those who are trained to both diagnose and offer prognosis for such defects. This, as Porteous (1985) observed, is still fraught with complexities. As Croome (1980) contended, every too often, components are judged to have failed if sufficient complaints are received about their conditions, and these complaints are not reliable indicators of the severity of failure. Especially in building, unless there is a serious and obvious structural failure, there is usually no focal point for complaints.
Porteous (1985) has noted that one of the factors which may decide whether a building defect is reported to some person competent to record and make judgement upon it is the ownership of the building. Local authorities who hold buildings as socio-investment units have a higher expectation of defect-free stock than owner-occupiers. Whilst the owner-occupier makes decision on defect strictly on commercial judgement, the local authority is looking for sound, trouble free investment for political reasons as dictated by the political interest of the central government.

5.10 Stock condition survey

Condition survey has been defined as an attempt at establishing the state of a dwelling or production unit with the overall objective of acquiring an informed knowledge of its state of repairs in order to forestall any likely loss of production resulting from sudden breakdown in the case of production units, and preservation of stock value in the case of buildings (Mole and Olubodun, 1995b).

Damen (1990) has identified some objectives of condition surveys as:

(a) to determine stock's need of repair
(b) to locate where quality deficiency exists
(c) to identify the type of operations necessary to correct the deficiencies
(d) to show whether existing maintenance policy is adequate or not
(e) to know whether certain measures yield the desired result.

5.10.1 Day-to-day survey

Contrary to the formalised pre-planned and systematic approach to overall stock assessment in condition survey, day-to-day reactive survey can be ad hoc or even haphazard to a greater or lesser extent. This is occasioned sometimes, by the whimsical and untrained impulse of dwellers (Croome, 1980) to what is considered to be an incursion of defect or a symptom of it. The practical implication of this is that it is extremely difficult for the surveyor to always carry out his investigation in a totally unbiased manner however theoretically professional that activity might be said to be. This situation is further complicated by the increasingly conscious 'consumer-oriented' society that we live in. The negative effect of which is for the surveyor to be positively biased in favour of pleasing the consumer (in this case the tenant or dweller) in his diagnosis and prognosis of reported defects. Nonetheless, reactive survey, more often than not helps to 'nip the problem on the board' and can be rightly described as 'a stitch in time that saves nine'.

5.10.2 The surveyor's bias

Surveyors engaged in the various types of stock surveys naturally vary in their opinion of defect causes and repair method. However, their variability should be within a normal distribution of opinions of a sample of proficient and qualified surveyors. However, careful training of surveyors engaged in surveys will go a long way towards enhancing uniformity, and concordance in opinions. O'dell (1990) from his own personal experience in the field came to a conclusion that surveyors do generally agree quite closely in their description of defects, with little disagreement in diagnosis but greater disagreement in their prognosis. This position lends credence to the research methods employed in the study since it falls short of requiring surveyors to proffer prognoses for identified defects but merely seeks their opinion as to the contributing influence(s) on defects. This improves reliability in the light of obvious subjectivity. This position is corroborated in parallel with O'dell (1990) by Damen (1990), as no two persons are likely to have the same outcome given the variable nature of the process of observation and interpretation.

5.11 The English House Condition Survey (EHCS)

The EHCS has been conducted every five years since 1967. Its purpose is to describe the housing stock and to monitor its changing condition, thereby providing background to government policies on home improvement and area renewal (O'Dell, 1990). The survey consists;

1. Of the physical examination of a large sample of the national stock; interviews with occupiers to determine the recent history of repair and maintenance to their homes, their interest in home improvement and ability to finance necessary work.
2. A postal survey of local authorities to determine the institutional contribution to housing renewal; and
3. A survey of house values (O'Dell, 1990).

The technique used in EHCS have developed gradually over the years. A longitudinal survey approach to reduce errors in the measurement of changes over time has become a standard practice. As claimed by O'Dell (1991), the survey is the chief vehicle for the collection of information by the DoE in support of all aspects of housing policy. From the mass of data available from this quinquenial survey, the initial expectation was that most of the data needed for the study could be obtained from the arsenal of maintenance information in the (EHCS) archive. Following from the global objective of the survey however, it is no surprise that the resulting data does not satisfy our data need for this study.

5.12 Organisation of Housing Management

5.12.1 Stockholder's responsibility - Housing Management

The council's responsibilities with regards to repairs and improvement is a contractual one, as enunciated in the Tenancy Agreement exchanged with tenants. The council binds itself to do the following:

- To keep every housing unit to a decent standard of repair.
- To paint window and door frames, and general external woodworks at regular intervals as preventative measure against disrepair.
- To effect repairs on any disrepair items in a reasonable time and tidy up after repair.
- The right to temporarily rehouse a tenant in the event that the dwelling has to be empty for major building work.

In the local authority being studied, there are broadly two operational areas namely; North and South. Within each operational area there are area housing offices each of which have responsibilities for between 3000 and 5000 housing units.

A typical area housing office organisation structure is shown in Figure 5.2

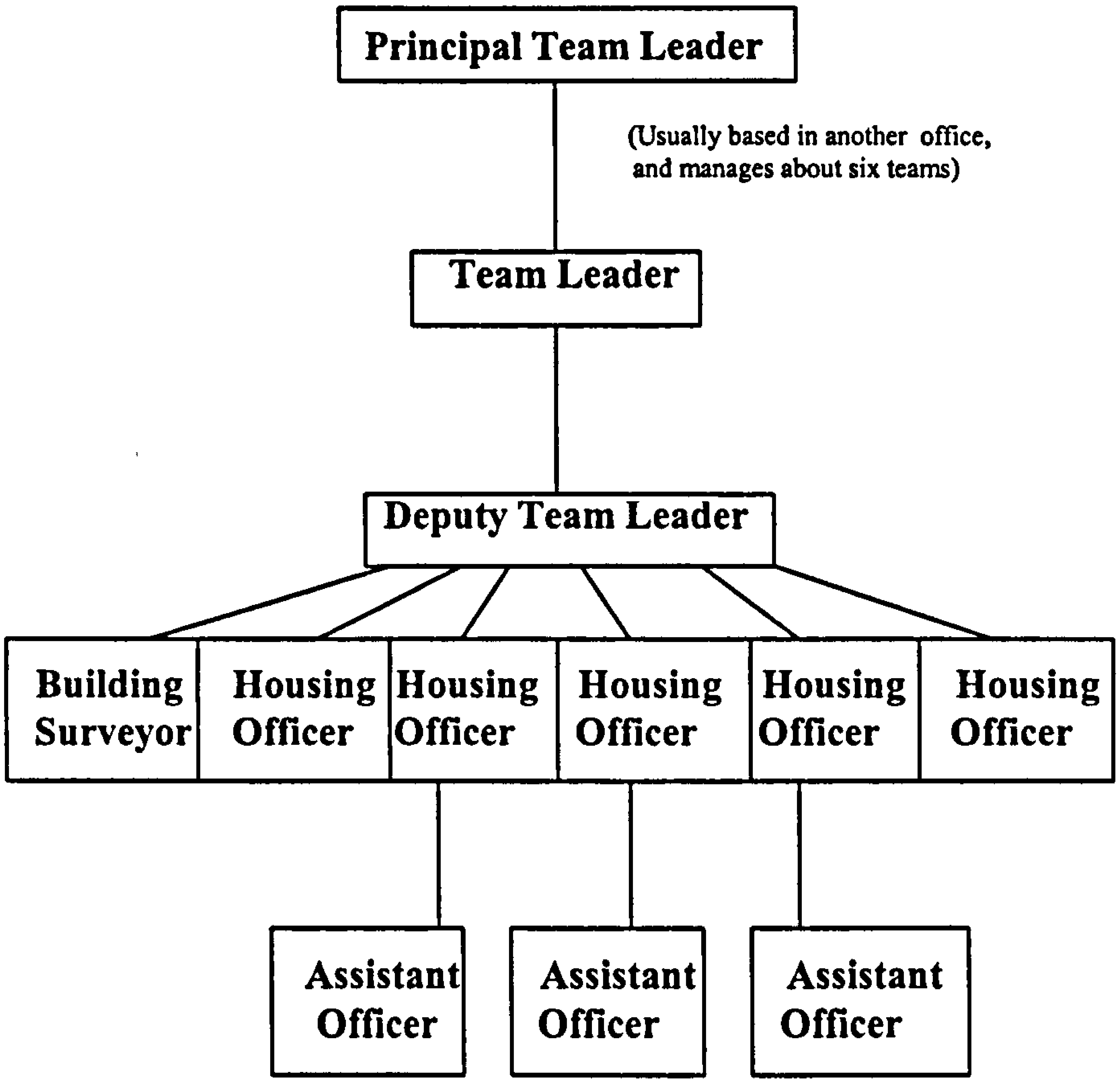


Figure 5.2: Organisation structure for local area housing management

5.12.2 Procedures for repair action

5.12.2.1 Defects reporting by tenants

A tenant is responsible for the behaviour of every person, including children living in or visiting his home. Every tenant is obligated by the tenancy agreement to inform the council about any defects or damage immediately.

When a repair is reported by a tenant, the receiving housing officer will immediately order the repair as required following departmental laid down procedures once the officer satisfies himself that the job has not already been ordered. Once ordered, a computer generated confirmation slip is given or sent to the tenant confirming his report. This receipt will show that the tenant had in fact met up with the requirement to report repairs needs if there is a problem in the future.

Where damage is caused deliberately or by neglect, the tenant is expected to carry out or pay for such repairs. Furthermore, the tenant is expected to do small repairs such as unblocking sinks, replacing taps or internal door handles. It is however often too difficult to prove where repair needs has been caused deliberately or by neglect. In the end, the responsibility to do repairs falls upon the council.

5.12.2.2 Housing officer's inspection

Repairs which are not prioritised as emergency would normally require housing officer's inspection. Such repairs are required to be inspected within five working days of report being made by tenant. Where the housing officer could not obtain access to the dwelling a 'no access' card is left giving details of job and requesting the tenant to reply within seven days and making arrangement for a mutually convenient time for a repeat visit by the housing officer. This visit is simply to ensure that the repair has been correctly ordered.

Once it has been decided that the repair is valid, the housing officer exercises his discretion as to whether or not the defect requires the expertise of a building surveyor for accurate diagnosis.

Repairs are divided into two groups, namely; those that require a pre-inspection to determine the work specification by building surveyors, and those which are routine repairs and can be ordered reasonably accurately without pre-inspection.

Where required, survey order request is raised by the housing officer for the surveyors' group for the housing area, if not, the job is processed through the computer system for the action of the DLO department. At this stage, a confirmation letter is sent to the tenant informing him/her that repair works will be carried out. The deadline by which the repair will be completed will either be 4 weeks from the day the repair order is sent to the DLO or 12 weeks from the day the survey request is sent to the surveyors as appropriate.

5.12.3 Local budgetary control

Each area housing team leader is allocated annual repairs budget and is responsible for controlling expenditure within those cash limits. In order to exercise control, the team leader requires an accurate estimate of their committed expenditure on a job by job and summary basis. What is conspicuously lacking at the moment is a pre-planned estimate of likely repair cost for a given year before the commencement of the financial year. This results in budget shortfalls and the most crucial repair needs have to be foregone in most area offices. In some instances surplus budgets tend to be inefficiently spent-up towards the end of the financial year in few area offices.

5.13 Summary

This chapter produced a review of related literature on factors determining or influencing maintenance needs namely; age, design, vandalism, construction type and changing standards. The place of tenants in the repair of their home through the instrument of the Tenants' Charter was clearly identified. The subjectivity in defect reporting culture on the part of both tenants and experts was discussed.

The influence of the mediatory role of local housing management in regulating and responding to maintenance need and requirements was discussed. The decision as to the validity of a tenant's report on defects rests with the housing officer, as well as response time within which such defects are attended to. Control of local budgets as they impact on responsiveness to repair was brought to the fore. Each area housing team leader is allocated annual repairs budget and is responsible for controlling expenditure within those cash limits. In order to exercise control, the team leader requires an accurate estimate of their committed expenditure on a job by job and summary basis. What is conspicuously lacking at the moment is a pre-planned estimate of likely repair cost for a given year before the commencement of the financial year. This results in budget shortfalls and the most crucial repair needs have to be foregone in most area offices. In some instances surplus budgets tend to be inefficiently spent-up towards the end of the financial year in few area offices.

CHAPTER 6
ANALYSIS OF SURVEYOR'S QUESTIONNAIRE

6.1 Introduction

The objective of this section is to analyse and interpret factors which bear upon building components and to explore underlying relationships among the number of building components forming construction entity from information provided by the respondents. A multivariate statistical technique known as factor analysis was chosen as the method of grouping the components into sub-patterns at exploratory level, and regression statistical technique at the confirmatory level.

The chapter is divided into two main segments. Section one is the analysis of data from the survey of building surveyors, which has been described as the primary analysis. While section two is the second analysis which is intended to explore and detect underlying relationships among the number of building components forming the construction entity. The format of presentation for each analysis is hypothesis, data, analysis and results, and interpretation.

6.2 Objective

Following from the literature review, authors are commonly agreed on factors pertaining to the building structure. What is at dispute is the extent to which these factors are important in causing defects. The impact of building structure family of factors is schematically illustrated in Figure 2.3 as derived from the literature. This family of factors have been identified to include Age factors, construction factors, Design factors, Changing Standard and Vandalism factors.

The objectives of this chapter are chiefly to:

1. Underscore the impact of each of the five criteria sets on the identified 28 building components (see section 2.8.3.3 on how the components are obtained). In so doing, it will be possible to appreciate the tangible influence of the factors in terms of how they affect defect causation on building components for the sample population.

2. Establish the relative importance of each of the five criteria in terms of individual contribution to overall defect. As a follow-up to this, the overall contribution to maintenance generation of "Building Structure Family of Factors" will be established in relation to other possible causes or factors.

6.3 The Thesis - Hypotheses

Three different hypotheses are explored in this chapter. The fourth is explored in Chapter Seven as a follow-up to the questions raised in the exploration of the third hypothesis. The hypotheses are set as follows:

A(i) Null hypothesis (H_0): No agreement can be found among the building surveyors in assessing the strength of each of design, construction, age, changing standard and vandalism as a causative factor for defects on building components, i.e. Kendall's Coefficient of Concordance is not significant at 5% level significance.

A(ii) Alternative hypothesis (H_1): There is agreement between the surveyors in assessing the strength of each of design, construction, age, changing standard and vandalism as a causative factor for defects on building components, i.e. Kendall's Coefficient of Concordance is significant at 5% level significance.

B(i) Null Hypothesis (H_0): Technical knowledge possessed by building surveyors, of the building is the most important ingredient in tracking down maintenance in housing properties.

In essence, a knowledge of design and construction characteristics, evolving standards, the level of exposure to vandalism and age of a dwelling will allow us to explain most of the variations in its maintenance requirements.

B(ii) Alternative Hypothesis (H_1): Technical knowledge possessed by building surveyors, of the building is not the most important ingredient in tracking down maintenance in housing properties.

C(i) Null Hypothesis (H_0) : Of the five factors identified, none is more important than the other for the prediction of housing maintenance requirements.

C(ii) Alternative Hypothesis (H_1): Of the five factors identified, some are more important than others for the prediction of housing maintenance requirements.

D(i) Null Hypothesis (H_0):There are no intercorrelations between component defect causes, i.e. it is not plausible to localise defect causing factors to a group of components.

D(ii) Alternative Hypothesis (H_1):There are intercorrelations between the components defect causes

Tool for the last set of hypothesis is the factor analysis in the next chapter.

6.4 The survey

One hundred active building surveyors were selected from the survey population, consisting of building surveyors and engineers employed by the Council. These all have direct involvement with defects diagnosis on the housing stock. Of these, 52 surveyors responded by returning their questionnaire. This represents a 52% response rate. However, of the returned questionnaire, seven were rejected for incomplete information, thus the analysis is based on 45 satisfactorily returned questionnaire, representing a final response rate of 45%. This response rate is still quite high for surveys of this type and is considered satisfactory (Russell *et al*, 1992). It is worthy of mention that the researcher's proximity to the population sample may have encouraged such a high response rate. Furthermore, Forsgren's (1986) view that the respondent's perception of the survey as touching on his field of interest very strongly influences response rate, is here supported as the subject of the questionnaire directly impinges on respondents' professional practice and field of employment.

6.5 Reasons for non-response

Forty-eight surveyors were believed to have declined to participate in the survey. In actual fact, more than 40% of these returned their completed questionnaire two to three months after the questionnaire was sent out. It was earlier decided before sending out the questionnaire that returned questionnaires would be considered valid if they were returned no later than six weeks after being sent out. It is believed that given the number of responses complying with the set time limit, not including the late questionnaires would not adversely affect the outcome of the survey. On the contrary, it implies that the responses analysed in the first instance are those from a cross section of participants possessing keen interest in the study and are indicative of deep interest and enthusiasm for the subject.

The responses were analysed according to the hypothesis they were intended to test.

6.6 Data collection, manipulation, analysis and presentation

6.6.1 The data

The organisation of the questionnaire designed to elicit information from respondent for the testing of the above hypothesis along with other related hypotheses is somewhat complex. Complex as it was, the implementation of a pilot study (section 2.5.2.3) alleviated any doubts as to understanding and clarity on the part of the participants. The need to keep the questionnaire short so as to maintain interest and enthusiasm on the part of the respondents was responsible for such complexity in the design of the survey instrument.

Question No. 1 asked for the respondent's job title in order to know, at what level of expertise the participant is carrying out building surveying functions. Questions Nos. 2 and 3 seek to elicit information on the experience of survey participants in order to gain some insight into the level of reliability the author can expect from the responses. Questions 4 and 5 are the very essence of the questionnaire. Question No. 4 asked primarily for each of the identified building components to be scored on each of the five factors, namely: design, construction, age, changing standard and vandalism as a defect causing influence. Question No. 5 asked respondents to rank the identified 28 building components according to how frequently defects show on them. This formed the basis for the exploratory data reduction technique - factor analysis of the next chapter. The suggested scores were: hardly ever [0], very occasional [1], occasional [2], frequent [3] and very frequent [4].

6.6.2 Missing values

An examination of the SPSS display of the results show that 431 scores (6.84% of the total data set) are missing. The effect of the missing values will be to reduce to 17 the number of valid cases having scores for all the variables. To correct for this unwelcome effect, each missing score is substituted with the mean of the respondents score for the variable; alternatively, the missing values can be substituted with random scores (after Norusis 1994 and Nkado 1991). In this case, it was decided to opt for 'mean substitution' for missing values, as this is commonly believed to be the more objective correction option.

6.6.3 Data Analysis

Each score given by a respondent represents the degree to which the occurrence of defects on a particular building component can be explained by the influence a particular defect causing factor has on that component. In a survey of this nature, incidence of repetitive scoring (Jobber 1986), which is an indication of lack of interest, or an indication of boredom may be expected to a lesser or greater extent. A cursory inspection however, shows no apparent use of a particular rank across the variables by any one respondent. A visual inspection of the pattern of scoring was done prior to the various statistical analyses being conducted. From the inspection carried out, there is nothing to suggest that thoughtful assessments have not been made and that respondents did not express their candid and enthusiastic opinion in both the scoring for Question No. 4 and ranking of components in Question No. 5.

6.6.3.1 Test for homogeneity across groupings

Whereas no validatory check-questions were included in the building surveyor's questionnaire, the issue of reliability of the responses was tested by conducting various analyses to test for significant differences in the scorings between respondent groups.

A one-way analysis of variance was conducted for each of the 135 variables derived from Questions Nos. 4 and 5 to test for differences between the mean scores of two groups of surveyors, i.e. building surveyors and senior building surveyors. This revealed the existence of significant differences (at the 5% level) between the groups for six out of the 135 variables (after Fortune and Skitmore, 1994). An analysis of variance (ANOVA) results print-out for six of the variables is shown in Table 6.1 It is expected that the test could prove significant on up to seven variables by mere chance occurrence, which is higher than the observed six in this case. On this evidence, it was decided to proceed further with the analysis without regard to surveyor's title or seniority. However, a similar analysis with length of experience as factor revealed that 21 out of the 135 variables proved to have significant 'F' ratios. This is more than would be expected by chance. Nevertheless, it is believed that this is not a strong enough evidence against proceeding with further analysis using the respondent groupings on length of experience. As shown in Table 6.4b, the distribution of experience between the two groupings is not nearly balanced. Whereas 12 (representing 27% of the sample) claimed to have spent more than five years with the technical consultancy unit, 33 (representing 73% of the sample) have not spent more than five years. The effect of this imbalance in the distribution will have been to distort the observed strength of significance in the analysis (after Champion, 1981). This explains why up to 15 per cent of the variables prove to be significant (which is considerably higher than the expected 5 per cent). The variation is underpinned by the distribution rather than by length of service.

Table 6.1: Analysis of Variance results for selected variables on job title.

- - - - - O N E W A Y - - - - -

Variable DAMPROFD DEFECTIVE DAMP PROOFING (DESIGN)
By Variable JOBTLE2 job tittle

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	2.6163	2.6163	2.0432	.1605
Within Groups	41	52.5000	1.2805		
Total	42	55.1163			

Variable DEFRUFD defective roof structure (design)
By Variable JOBTLE2 job tittle

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.4901	1.4901	.9098	.3455
Within Groups	43	70.4211	1.6377		
Total	44	71.9111			

Variable RUTD dry/wet rot (design)
By Variable JOBTLE2 job tittle

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	3.8413	3.8413	2.3183	.1357
Within Groups	40	66.2778	1.6569		
Total	41	70.1190			

Table 6.1 (cont'd)

Variable WATINGD water ingress (design)
By Variable JOBTLE2 job tittle

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.5730	.5730	.3178	.5760
Within Groups	41	73.9386	1.8034		
Total	42	74.5116			

Variable BUSTD broken pipe or appliance (design)
By Variable JOBTLE2 job tittle

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3889	.3889	.8589	.3596
Within Groups	40	18.1111	.4528		
Total	41	18.5000			

Variable REGLAZD reglazing (design)
By Variable JOBTLE2 job title

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0194	.0194	.0368	.8488
Within Groups	42	22.1624	.5277		
Total	43	22.1818			

The conclusion drawn from these two sets of analyses is largely that scores do not vary with surveyors across job titles or length of service, i.e. that the scores are reasonably homogeneous.

6.6.3.2 Methods

The purpose of this section is to present a statistical analysis of the manipulated sample data on identified building component defect's assessment and tangible causes of defects, and to test the first three sets of hypotheses set out in section 6.3.

Before going into the details of the analyses carried out on the data, it is necessary to explain the statistical tests and methods used. These methods are chosen as those most applicable to the data sets.

6.6.3.2.1 The Kendall coefficient of concordance, W

Kendall's coefficient of concordance, W, measures the extent to which there is agreement between the rankings on any number of variables. In essence, it determines the significance of agreement between building surveyors in ranking the variables. It is a method of determining the degree of agreement between 'k' respondents on 'n' variables where each has been measured on an ordinal scale. In this study, it is used to test the null hypothesis that the 45 sets of rankings on the 28 variables are independent or unrelated at each of the five factor levels, at the 5% significance level.

There are three non-parametric rank correlation tests: Kendall's (τ); Spearman's (ρ)rank correlation coefficients; and Kendall's coefficient of concordance (ω) (Hays 1988 and Siegel, 1956). The first two are impractical for large values of N since all possible values of the coefficient for each pair of respondents must be averaged (Siegel, 1956). The third, Kendall's coefficient of concordance (ω), was therefore the most appropriate measure to apply in the case of this study.

Kendall's Coefficient of Concordance (ω) is expressed by Siegel (1956), Champion (1981) and Hays (1988) as:

$$\frac{\textit{Variance of Ranked Sums}}{\textit{Maximum possible Variance of Rank Sums}}$$

Hence,

$$= \frac{12S}{N^2(n^3 - n)}$$

where

N is the number of rankings (respondents)

n is the number of ranks (items ranked)

S is the observed sum of the squares of deviations of sums of ranks from the mean value, $\frac{1}{2}N(n+1)$.

There are two principal tests used to check the hypothesis that there is agreement between the judges in ranking n variables.

These are as follows:

i) For n < 7, a chi-square test is used (Hays, 1988)

where

$$X^2 = N(n-1)\omega = \frac{12S}{Nn(n+1)}$$

ii) For n > 7, the significance of the Kendall's Coefficient of Concordance may be determined by applying the formula for chi-square given above, with degrees of freedom given by (n-1). A significant chi-square confirms a significant (ω) (Cohen and Holliday, 1982; and Siegel and Castellan, 1988).

6.6.3.2.2 Chi-square test for independence

This statistic is a single-sample test of significance, which can be extended to two independent-sample test. The procedures for chi-square statistic is commonly referred to as goodness-of-fit tests. This label applies to the 'fit' between an observed set of frequencies across a given number of categories or in a nominal crosstabulation of variables, and an expected set of frequencies.

The statistic ω proposes a hypothesis of independence or an approximation to independence. Independence implies that knowing the value of one variable says nothing about the values of the other. Conversely, the absence of independence suggests that at least some categories are associated. The test rests upon the assumption of asymptosis and multinomiality. By these, it is implied that the expected frequency must be reasonably large not to produce misleading inferences. As a rule of thumb, Champion (1981) suggested that the sample size must be 25 or larger, and randomly selected. In our case, these two crucial conditions of asymptosis and multinominiality are met as the sample size is 45 and fixed by the sample design in order to ensure that the responses are independent. The third and fundamental assumption of the test is that the possible responses are mutually exclusive and of course, exhaustive. As a respondent can not give more than one response to any of the variables, the condition of mutual exclusiveness is met in the design of the questionnaire. To every intent and purpose, it is believed that mutual exhaustiveness is ensured through the piloting of the survey instrument.

6.6.3.2.3 Mean Rank

The development of a mean rank for each of the variables works upon the SPSS recognising the pattern of scoring for each variable. In this study, the scores are assigned to the variables as follows:

Hardly ever - 0 Very occasional - 1 Occasional -2

Frequent - 3 Very frequent - 4.

These scores are treated as ranks for the computation of the Kendall's Coefficient of Concordance (ω) statistic. The highest score is assigned to the most popular variable as perceived by the respondents. The mean rank is obtained by computing

$$\frac{\sum_{j=1}^{28} R_j}{N}$$ for each variable, that is building component (Siegel, 1956).

Where;

R_j is score assigned to the variable by each respondent and,

N is the number of rankings (respondents).

This quantity is automatically multiplied by 10 in SPSS software in every case in order to ensure that every variable attains a figure of no less than 1.0. This quantity, here referred to as mean rank (SPSS) measures the relative dominance of each variable within the final statistic (ω). In this study, the variable with the highest mean rank is the most dominant while the variable with the least mean rank is the least dominant.

6.6.3.2.4 Multiple linear regression

The general form of a multiple linear regression can be written as:

$$Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + ... + \beta_n X_{ni} + \varepsilon_i \qquad \textbf{Eqn 1}$$

Where Y is the predicted variable, β_0 represents the constant term, $X_n^{'s}$ represent the independent variables and $\beta_n^{'s}$ represent the coefficient of each of the 'n' variables in the equation.

The underlying assumption of the above equation is that the independent variables are related to the dependent variable in a linear way. That is to say, the equations included no variables as products or powers of itself.

Given a logarithmic transformation on the original data to convert it to an interval scale measurement, the general form of the regression equation from **equation 1** can be changed as follows:

$$\log Y = \log\beta_0 + \log\beta_1 + \log X_{1i} + \log\beta_2 + \log X_{2i} + ... + \log\beta_n + \log X_{ni} + \quad , \qquad \textbf{Eqn 2}$$

According to Neal and Shone (1976), there is a systematic relationship between $\log Y$ and $\log X_{ni}^{'s}$.

The variables are now $\log Y$ and $\log X_{ni}^{'s}$, while the parameters are $\log\beta_0$ and $\log\beta_n^{'s}$, and ε is normally distributed with $\lambda = 0$, $\delta^2 = 1$

The advantage of the transformed equation lies in the fact that the variation in maintenance need as a result of a possible change in each one of the independent variables are the parameters of the equation.

6.6.3.2.5 Multiple Regression Statistics

The output of a regression analysis contains the following terms:

Multiple R: This is a measure of the linear relationship between the dependent variable and the independent variables. It is described as the correlation between the observed dependent variable, Y and the fitted variable, $\hat{Y}$ from the independent regressor variables in the equation (Gilchrist, 1984). It is the positive square root of R^2. As with R^2 from which it is derived, its value is 1.0 if all the observed values fall on the regression line, and it assumes zero value if there is no linear relationship between the dependent and independent variables.

R Square R^2**:** This is called the coefficient of determination and it is the proportion of the variance of the values of Y explained by the regression equation (Norusis, 1990). Accordingly, Gilchrist (1984) and Norusis (1990) have described at it as a measure of the goodness of fit of a particular model.

$$R^2 = 1 - \frac{\text{Residual sum of squares}}{\text{Total sum of squares}}$$

Adjusted R square (R_a^2)**:** This expressed as:

$$\left(R_a^2\right) = R^2 - \frac{p(1-R^2)}{N-p-1}$$

Where N is the number of cases and p is the number of independent variables in the regression equation. It attempts to estimate for the population as against the sample from which the statistic is derived. Whereas the sample R^2 tends to be an optimistic estimate of how well the model fits the population, R_a^2 attempts to correct R^2 for the number of variables included in the model (Norusis, 1990). It does not automatically increase as a new variable is added to the model, unlike R^2.

F - statistics: This is the standard deviation of the residuals.
The total observed variability in the dependent variable is subdivided into two components, namely; that which is attributable to the regression and that which is not (Norusis, 1991). The F-test is associated with the analysis of variance of the regression model. It tests the null hypothesis that $\beta_n = 0$. If this hypothesis is significant, it leads us to reject the null hypothesis that $R^2 = 0$, in other words, it is a test of whether there is a linear relationship between the dependent variable and the entire set of independent variables.

β *cofficients*: These are the partial regression coefficients, partial because the coefficient for each variable is adjusted for other regressor variables in the equation.

Beta: A way to make regression coefficients more comparable is to calculate the beta weight, which are the coefficients of the independent variables when all variables are standardised. It is computed as $\beta_k' = \beta_k \frac{S_k}{S_y}$ (Norusis, 1991)

Where S_k is the standard deviation of the kth independent variable, S_y is the standard error of the estimate and β_k is the β coefficient of the kth variable. Kinnear and Gray (1994) interpreted this score as the proportion of one standard deviation change in the dependent variable made by a one standard deviation change in the independent or kth regressor variable. Beta scores are indicators of the relative importance of the variables in the equation, and depend on the other independent variables in the equation.

Partial correlation coefficient: According to Norusis (1990), another way of assessing the relative importance of independent variables is to consider the increase in R^2 when a variable is entered into an equation that already contains the other independent variables. The square root of the increase is called the part correlation coefficient. This coefficient is computed by as follows:

$$\Pr_i^2 = \frac{R^2 - R_{(i)}^2}{1 - R_{(i)}^2}$$

where $Rr_{(i)}^2$ is the square of the multiple correlation coefficient when all independent variables except the ith are in the equation.

Tolerance: This is the proportion of the variability in the ith variable which is not explained or accounted for by the other variables in the equation. If the tolerance is low, it indicates that multicollinearity is a problem.

t - test: This statistic is expressed as $t = \frac{\mathrm{B}}{SE(\mathrm{B})}$

It is used to test the null hypothesis that the partial regression coefficient for the ith variable, $\Pr_i$, is equal to zero. A significant t - test indicates the existence of a linear relationship.

6.6.3.2.6 Mechanics of the scorings by respondents

The questionnaires were designed to allow all of the 28 building components to be scored on the basis of respondent's perception on each of the five criteria of design, age, construction, changing standard and vandalism as causative factors for defects. In other words, a respondent is expected to score each component (between 0 and 4) on the basis of his perception of the extent to which defect on the component is attributable to Design factors. This process is then repeated for all the other four criteria, i.e. Age, Construction, Changing Standard and Vandalism factors.

Each of the resulting groups (five in number) of data is analysed.

6.7 Data Manipulation

Reynolds (1977) has criticised the widespread tendency among researchers to compress variables into small, manageable number of categories, on the account that it may produce erroneous conclusions. He suggested that such compression of variable should not be done aimlessly, but should be dictated by statistical necessity where to do otherwise may lead to an unsatisfactory application of a statistical model. One instance where this is recommended according to Reynolds (1977) and Champion (1981) is where there is the need to overcome the problem of few expected cell frequencies and logical combinations of cells are possible.

In this case, neither of these two conditions is violated. Further to Question No. 1 which asked for respondent's current job title, five categories of responses are possible. However, as can be seen in the Tables, this will lead to an expected frequency of less than five on all the 16 or 20 cells. This condition would result in a misleading chi-square value. For the same reason, it was also decided to collapse the first and second responses on Question No. 3 (which asked for how long the respondent has worked with the Technical Department of the Council) as the actual cell frequency on the category 'Less than 1 year' is unacceptably too low. Tables 6.2a, 6.3a and 6.4a show the frequency distribution for Question Nos. 1 to 3 respectively; and Tables 6.2b, 6.3b and 6.4b show the corresponding collapsed categories for the same.

In line with Champion's (1981) and Reynolds' (1977) recommendations for manipulating nominal data, it has been decided to collapse the variable categories elicited from Question Nos. 1 to 3 as follows in Tables 6.2b, 6.3b and 6.4b.

6.8 Analysis of results on Building characteristics

6.8.1 Questionnaire responses by job title

Table 6.2a shows that 53% of the sample population are building surveyors (usually without management responsibilities), 20% are senior building surveyors, 4% compliance officer (responsible for monitoring defects on all repair works carried out), about 18% are principal building surveyors (who are at the interface between executing and managing surveys in each local office), and 4% surveying managers (they do not have practical surveying roles, but are responsible for providing feedback information on state of housing stock at each local office to senior management team for the purpose of policy formulation). The job title distribution of the respondents indicates that thoughtful assessments have been made and that the surveyors actually expressed their opinion in scoring and ranking the variables on each factor criterion, as requested. In the collapsed form, all surveyors without any management responsibility are grouped into one category; namely, building surveyors and compliance officers are collapsed into the **building surveyor** category. All the remaining three categories, i.e. senior and principal surveyors, and surveying manager are grouped together into the **senior building surveyor** category.

Table 6.2a: Surveyor's questionnaire by job title

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
BUILDING SURVEYOR	1	24	53.3	53.3	53.3
SENIOR BUILDING SURV	2	9	20.0	20.0	73.3
COMPLIANCE OFFICER	3	2	4.4	4.4	77.8
PRINCIPAL SURVEYOR	4	8	17.8	17.8	95.6
SURVEYING MANAGER	5	2	4.4	4.4	100.0
	Total	45	100.0	100.0	

Table 6.2b: Surveyor's questionnaire by job title (collapsed)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Surveyor (No Mgm't fn)	1	26	57.8	57.8	57.8
Surveyor (With Mgm't fn)	2	19	42.2	42.2	100.0
	Total	45	100.0	100.0	

Table 6.3a: Surveyor's questionnaire by length of service (L.A.)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
LESS THAN ONE 1 YEAR	1	3	6.7	6.7	6.7
1 TO 5 YEARS	2	19	42.2	42.2	48.9
6 TO 10 YEARS	3	8	17.8	17.8	66.7
11 TO 15 YEARS	4	6	13.3	13.3	80.0
16 TO 20 YEARS	5	5	11.1	11.1	91.1
MORE THAN 20 YEARS	6	4	8.9	8.9	100.0
	Total	45	100.0	100.0	

Table 6.3b: Surveyor's questionnaire by length of service (L.A.) - collapsed

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
not exceeding 5 year	1	22	48.9	48.9	48.9
exceeding 5 years	2	23	51.1	51.1	100.0
	Total	45	100.0	100.0	

Table 6.4a: Surveyor's questionnaire by length of service (Dept.)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
LESS THAN 1 YEAR	1	7	15.6	15.6	15.6
1 TO 5 YEARS	2	26	57.8	57.8	73.3
6 TO 10 YEARS	3	12	26.7	26.7	100.0
	Total	45	100.0	100.0	

Table 6.4b: Surveyor's questionnaire by length of service (Dept.) - collapsed

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
≤	1	33	73.3	73.3	73.3
▷	2	12	26.7	26.7	100.0
	Total	45	100.0	100.0	

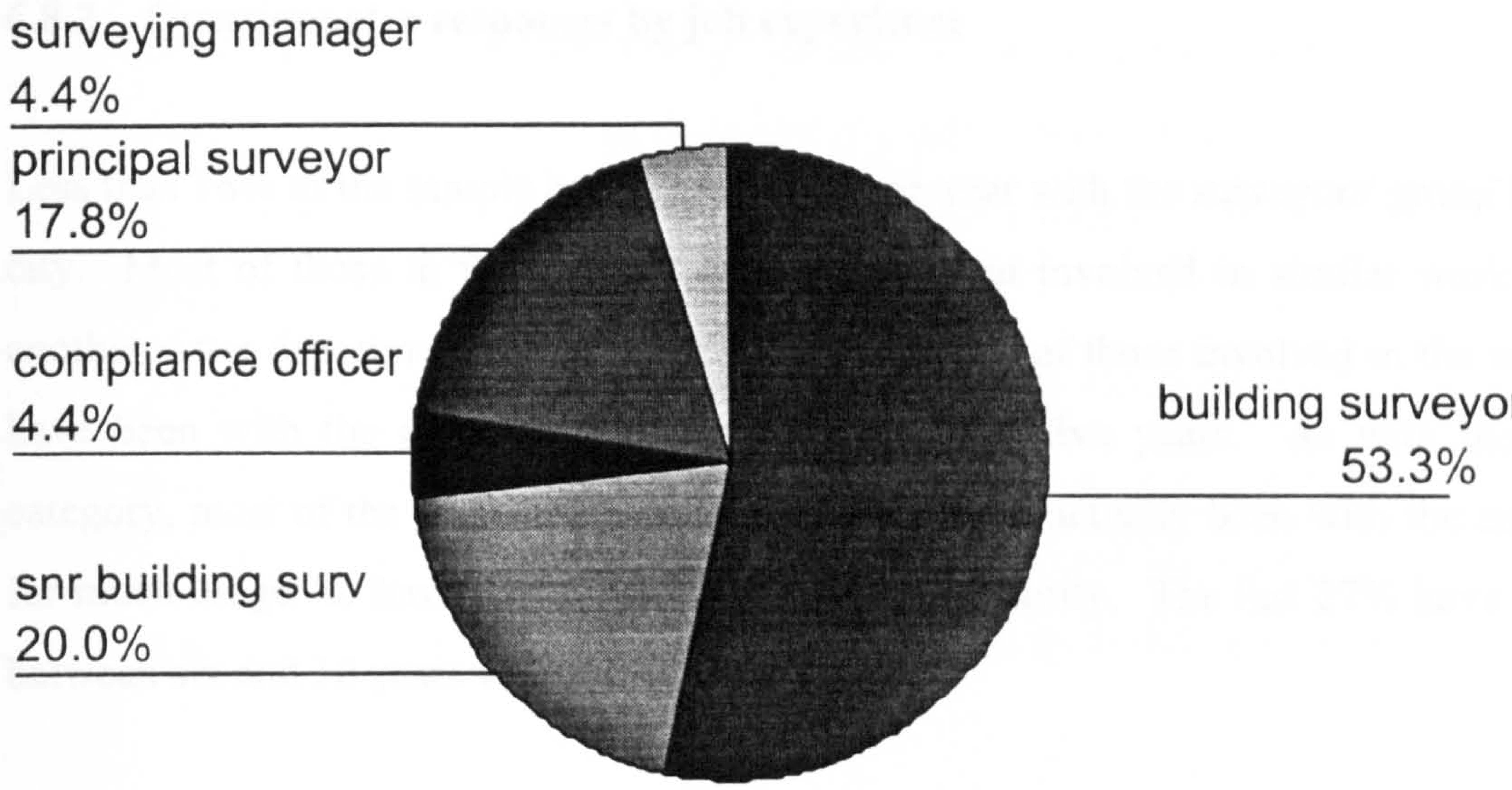


Figure 6.1: Breakdown of questionnaire by job title

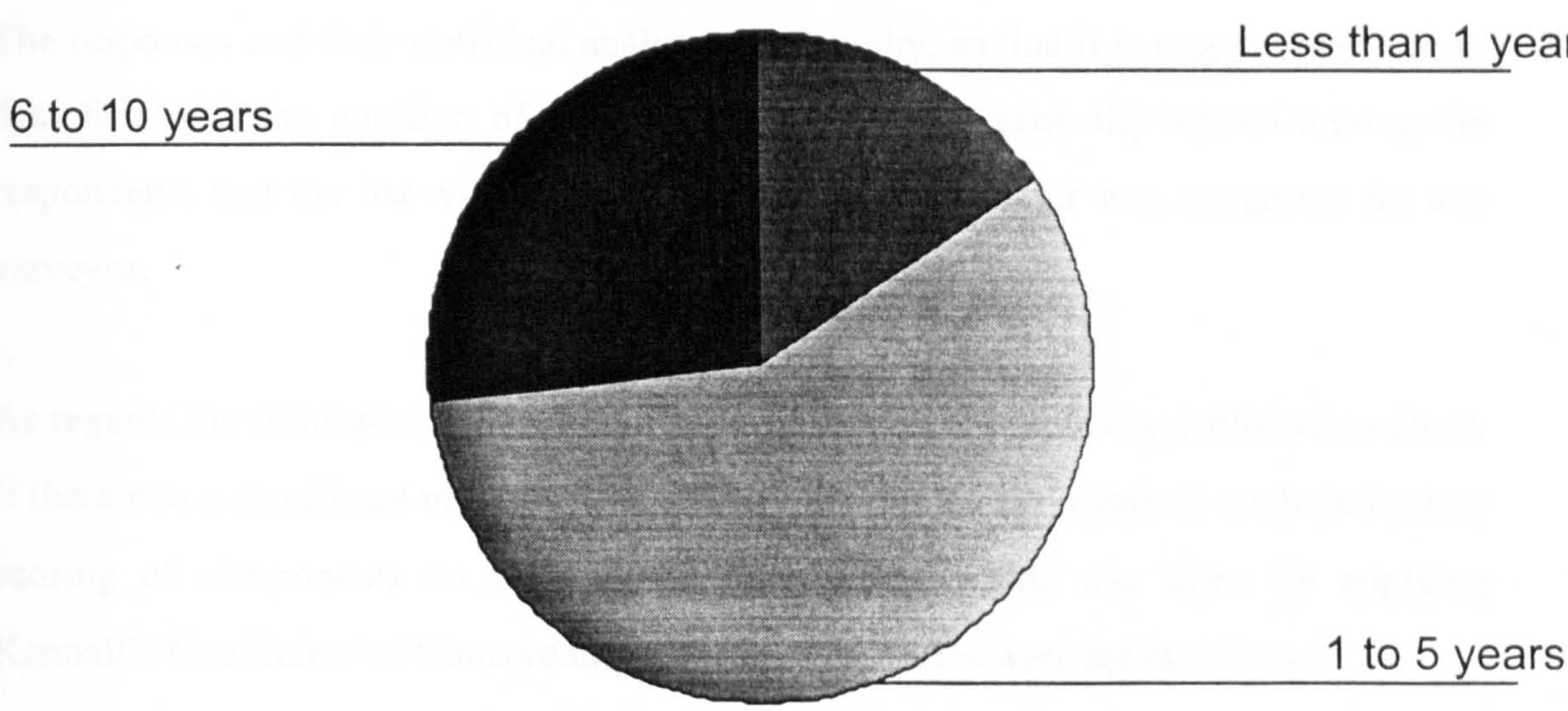


Figure 6.2: Breakdown of questionnaire by length of service with department

6.8.2 Questionnaire responses by job experience

Less than 16% of the sample has had less than one year with the surveyors' group in the city. Most of those in this group have actually been involved in similar work with another sister department of the council. The majority of those involved in the survey have been with the department for between one and five years. As with the first category, most of the respondents in this category have actually been with the council for much longer or have come from another local authority. The last 27% have spent between six and 10 years with the department.

6.9 Discussion of Results on Building characteristics survey - Section One

In considering the purpose and the strategy of the questionnaire the content can be divided into five main categories. Namely, those concerned with the influence of design, construction, age, changing standard and vandalism as primary causative factor for defect on identified building components. The responses to different building components identified were analysed by mean rank analysis.

The responses and their statistical analyses are lengthy, so that it is more convenient to deal first with the question of comprehensives. It was generally agreed among the respondents that the list was exhaustive, since no other factor was suggested by any surveyor.

As regards the seriousness of the scoring, a statistical test was first established to check if there was a significant measure of agreement among the surveyors as a whole in their scoring of components on each of the five factors. This was done by applying Kendall's Coefficient of Concordance, and the hypotheses were set as follows:

(i) Null hypothesis (H_0): No agreement can be found among the building surveyors in assessing the strength of each of design, construction, age, changing standard and vandalism as a causative factor for defects on building components, i.e. Kendall's Coefficient of Concordance is not significant at 5% level significance.

(ii) Alternative hypothesis (H_1): There is agreement between the surveyors in assessing the strength of each of design, construction, age, changing standard and vandalism as a causative factor for defects on building components, i.e. Kendall's Coefficient of Concordance is significant at 5% level significance.

The statistical model for K related samples, the Kendal (ω), in the Statistical Package for Social Science (Windows) was used for the analysis. The results obtained are as shown in Table 6.5 to Table 6.10b:

Table 6.5: Strength of Design Factors on Building Component Defects

Mean rank	Variable	Variable label
8.69	IDOORD	Internal door repair or replacement
8.90	REGLAZD	Reglazing
9.04	GASLEAKD	Gas leakage
9.29	XDOORD	Damaged security door
9.60	BUSTD	Broken pipe or appliance
10.50	LIFTRMD	Lift room repair
10.69	ELECFOTD	Electrical faults
10.75	FLASHD	Bay, canopy and chimney flashing
10.85	GRAFITD	Removing graffiti
10.88	DAMGOODD	Damaged rainwater goods
11.42	HEATD	Heating repair or replacement of part
11.71	FENCED	Fencing repair or replacement
13.27	WLTIESD	Wall ties failure
13.77	STACKSD	Soil stack (high rise)
14.19	PACHRFD	Patch repair to roof
15.15	BKDRAIND	Blocked drain
15.79	BKFLOWD	Soil pipe backflow
15.81	CONCRPRD	Balcony concrete repair
16.90	WATINGD	Water ingress
17.71	DAMPROFD	Defective damp proofing
17.96	DEFRUFD	Defective roof structure
18.35	SPALBKD	Spalled brick
18.85	XPANELD	External storey panel
19.63	RUTD	Dry or wet rot
20.15	SLABD	Slab and screed failure
21.21	CODENSED	Condensation problem
22.06	DPFLRD	Damp floor
22.90	XCRACKD	Expansion crack

Table 6.5b: Kendall Coefficient of Concordance test (listwise deletion of missing values)

Cases	W	χ^2	DF	Significance
24	.3694	239.3716	27	0.0000

Table 6.6: Strength of Age Factors on Building Component Defects

Mean rank	**Variable**	**Variable label**
5.84	GRAFITA	Removing graffiti
8.08	REGLAZA	Reglazing
8.32	CODENSEA	Condensation problem
8.38	BKFLOWA	Soil pipe backflow
8.98	XCRACKA	Expansion crack
9.76	XDOORA	Damaged security door
10.70	DPFLRA	Damp floor
10.96	LIFTRMA	Lift room repair
11.68	BKDRAINA	Blocked drain
11.70	SLABA	Slab and screed failure
12.60	RUTA	Dry or wet rot
12.88	IDOORA	Internal door repair or replacement
13.56	GASLEAKA	Gas leakage
14.76	BUSTA	Broken pipe or appliance
15.02	SPALBKA	Spalled brick
15.80	STACKSA	Soil stack (high rise)
16.18	XPANELA	External storey panel
16.30	WATINGA	Water ingress
17.38	DAMPROFA	Defective damp proofing
17.82	DEFRUFA	Defective roof structure
17.90	DAMGOODA	Damaged rainwater goods
18.14	HEATA	Heating repair or replacement of part
19.56	FENCEA	Fencing repair or replacement
19.60	CONCRPRA	Balcony concrete repair
20.24	ELECFOTA	Electrical faults
20.38	FLASHA	Bay, canopy and chimney flashing
21.28	WLTIESA	Wall ties failure
22.20	PACHRFA	Patch repair to roof

Table 6.6b: Kendall Coefficient of Concordance test (listwise deletion of missing values)

Cases	W	χ^2	DF	Significance
25	.3742	252.6174	27	0.0000

Table 6.7: Strength of Construction Factors on Building Component Defects

Mean rank	Variable	Variable label
8.77	GRAFITC	Removing graffiti
9.56	ELECFOTC	Electrical faults
9.58	REGLAZC	Reglazing
9.85	IDOORC	Internal door repair or replacement
10.31	BUSTC	Broken pipe or appliance
10.88	XDOORC	Damaged security door
11.06	DAMGOODC	Damaged rainwater goods
11.13	FENCEC	Fencing repair or replacement
11.19	HEATC	Heating repair or replacement of part
11.27	LIFTRMC	Lift room repair
12.50	GASLEAKC	Gas leakage
13.50	FLASHC	Bay, canopy and chimney flashing
14.06	BKFLOWC	Soil pipe backflow
14.75	STACKSC	Soil stack (high rise)
15.19	SPALBKC	Spalled brick
15.38	XCRACKC	Expansion crack
15.44	PACHRFC	Patch repair to roof
15.48	DEFRUFC	Defective roof structure
15.54	XPANELC	External storey panel
15.90	WLTIEC	Wall ties failure
17.21	BKDRAINC	Blocked drain
17.63	CODENSEC	Condensation problem
18.15	CONCRPRC	Balcony concrete repair
18.19	DAMPROFC	Defective damp proofing
18.83	WATINGC	Water ingress
22.10	DPFLRC	Damp floor
20.15	SLABC	Slab and screed failure
22.42	RUTC	Dry or wet rot

Table 6.7b: Kendall Coefficient of Concordance test (listwise deletion of missing values)

Cases	W	χ^2	DF	Significance
24	.3020	195.6734	27	0.0000

Table 6.8: Strength of Vandalism Factors on Building Component Defects

Mean rank	Variable	Variable label
7.75	WLTIESV	Wall ties failure
7.79	DAMPROFV	Defective damp proofing
8.08	XCRACKV	Expansion crack
8.81	CONDENSEV	Condensation problem
8.85	SLABV	Slab and screed failure
9.40	DPFLRV	Damp floor
10.00	BKFLOWV	Soil pipe backflow
10.13	RUTV	Dry or wet rot
10.29	SPALBKV	Spalled brick
10.69	CONCREPRV	Balcony concrete repair
11.13	DEFRUFV	Defective roof structure
11.29	XPANELV	External storey panel
11.98	STACKSV	Soil stack (high rise)
13.23	LIFTRMV	Lift room repair
13.27	BKDRAINV	Blocked drain
13.73	HEATV	Heating repair or replacement of part
14.35	PACHRFV	Patch repair to roof
14.92	WATINGV	Water ingress
14.71	ELECFOTC	Electrical faults
15.52	GASLEAK	Gas leakage
18.37	FLASHV	Bay, canopy and chimney flashing
20.37	BUSTV	Broken pipe or appliance
21.56	DAMGOODV	Damaged rainwater goods
22.13	FENCEV	Fencing repair or replacement
22.77	IDOORV	Internal door repair or replacement
24.87	REGLAZV	Reglazing
24.96	XDOORV	Damaged security door
25.06	GRAFITV	Removing graffiti

Table 6.8b: Kendall Coefficient of Concordance test (listwise deletion of missing values)

Cases	W	χ^2	DF	Significance
26	.6153	431.9688	27	0.0000

Table 6.9: Strength of (Changing Standard) Factors on Building Component Defects

Mean rank	**Variable**	**Variable label**
12.02	IDOORS	Internal door repair or replacement
12.02	BKFLOWS	Soil pipe backflow
12.40	WATINGS	Water ingress
12.56	LIFTRMS	Lift room repair
12.94	REGLAZS	Reglazing
13.02	DAMGOODS	Damaged rainwater goods
13.02	PACHRFS	Patch repair to roof
13.04	GRAFITS	Removing graffiti
13.10	BKDRAINS	Blocked drain
13.12	RUTS	Dry or wet rot
13.18	SLTIESS	Wall ties failure
13.20	SLABS	Slab and screed failure
13.48	CONCRPRS	Balcony concrete repair
13.94	DPFLRS	Damp floor
13.94	SPALBKS	Spalled brick
13.98	BUSTS	Broken pipe or appliance
14.00	FLASHS	Bay, canopy and chimney flashing
14.70	XPANELS	External storey panel
14.70	XDOORS	Damaged security door
14.80	DAMPROFS	Defective damp proofing
14.88	STACKSS	Soil stack (high rise)
14.96	XCRACKS	Expansion crack
15.14	FENCES	Fencing repair or replacement
15.26	DEFRUFS	Defective roof structure
15.58	GASLEAKS	Gas leakage
18.68	HEATS	Heating repair or replacement of part
21.22	ELECFOTS	Electrical faults
23.12	CONDENS	Condensation problem

Table 6.9b: Kendall Coefficient of Concordance test (listwise deletion of missing values)

Cases	W	χ^2	DF	Significance
25	.2596	175.2334	27	0.0000

Table 6.10: Combined ranking of Building Components

Mean rank	**Variable**	**Variable label**
19.48	BKFLOW	Soil pipe backflow
19.13	LIFTRM	Lift room repair
19.09	XPANEL	External storey panel
17.81	GRAFIT	Removing graffiti
17.49	FENCE	Fencing repair or replacement
17.41	CONCRPR	Balcony concrete repair
17.39	GASLEAK	Gas leakage
17.07	IDOOR	Internal door repair or replacement
16.43	SPALBK	Spalled brick
16.34	SSTACK	Soil stack (high rise)
15.89	ELECFOT	Electrical faults
15.87	HEATING	Heating repair or replacement of part
15.63	XDOOR	Damaged security door
15.67	FLASH	Bay, canopy and chimney flashing
15.41	BUST	Broken pipe or appliance
15.18	WLTIES	Wall ties failure
14.92	XCRACK	Expansion crack
14.37	SLAB	Slab and screed failure
14.29	DEFRUF	Defective roof structure
13.90	DAMGOOD	Damaged rainwater goods
13.67	BKDRAIN	Blocked drain
13.30	RUT	Dry or wet rot
11.87	PACHRF	Patch repair to roof
11.71	REGLAZE	Reglazing
10.86	DPFLR	Damp floor
7.56	WATING	Water ingress
5.77	DAMPROF	Defective damp proofing
2.51	CODENSE	Condensation problem

Table 6.10b: Kendall coefficient of concordance test (listwise deletion of missing values)

Cases	W	χ^2	DF	Significance
45	.3064	372.2350	27	0.0000

In Table 6.10a, the most frequently occurring defect has the lowest mean rank as the ranking in response to Question No. 5 required that the most popular component defect is ranked 1 and the next, 2 and so on. This explains the observed disparity between this Table and the preceding Tables.

6.9.1 Criterion Impact on Building Component Defects

6.9.1.1 Design Factors

Tables 6.5 and 6.5b show the results of the building surveyors' responses to the scoring of design influence on components. The five most affected components as a result of design faults appear to be 'wall cracks' (including superficial and structural), dampness in solid floor, condensation, slab failure and rot problems (which include wet and dry rot).

Design generally has not only to do with building or housing morphology, but equally with specification and construction methods. Cracks to walls are most frequent over windows and doors (ranging from severe to hairline cracks), where there is failure of lintel. Damp floor is often associated with solid floors, frequently used in ground floor back room and kitchen. In such instances, a case for misplaced design choices is inferred. It is not unusual to find cases where damp proof membranes to solid floors have failed, or even not been provided.

The problem of condensation is very much connected with overall climatic condition of the country. This necessitates the use of forms of housing designs which limit the amount of air movements that can be allowed within the dwelling within comfort level limits. This places unhealthy limits on window designer's provision for vents in window units. Unfortunately this is rarely matched by the provision of the required supplementary extract system to keep air changes within the internal environment at an ambient level.

Slab failure, as with damp floor problems, is common with solid concrete floor. The causes of failure may range from serious structural movement in the ground to inadequately protected services directly beneath the floor screed. Rusting of electric pipes have been known to result in swellings which cause the floor screed to crack up.

Wet rot is a more common problem than its counterpart dry rot. This finds its root in dampness causing situations in the building, and has much to do with use rather than design.
The implication of these observations is that the impact of design faults is most poignantly revealed on these five components namely; wall cracks, dampness in solid floor, condensation, slab failure and rot problems. If any of these components under perform, the solution would most likely be found in the examination of the nature of design and possible faults inherent in the design, or a combination of criteria which consists of design criterion.

The five least affected components as a result of design faults are internal doors, reglazing, gas leakage, security door and broken pipe or appliance. It is noteworthy that none of these five relate to the actual fabric of the building, but all relate to fittings of some kind to the main frame of the building. This leads one to suggest that design improvement on housing should focus more on building frame and its morphology rather than on fittings and fixtures.

6.9.1.2 Age Factors

Tables 6.6 and 6.6b show the results of the building surveyors' responses to the scoring of age influence on components. The five most affected building components due to age are minor damages to roof requiring patching up, wall tie failure, flashing problems, electrical faults and concrete spalling. The inclusion of defective roof patches and electrical faults in the top five components explains the rationale for the commonness of wholesale electrical rewiring and roof renewal works on a number of council dwellings. The observation constitutes a sound basis for preventative programme works on each of these five components as a result of age. In other words, re-roofing, wall tie replacement, flashing renewal, electrical re-wiring and general concrete repairs should constitute priority preventative programme works on the sampled dwellings. Such programmes should be decided on account of age and estimated failure time of the components concerned.

The five least 'age vulnerable' components are graffiti related damage, broken panes, condensation, backflow problems and Cracks to walls. It is surprising that 'cracks to walls' is one of these five components. Ordinarily, one would have posited that age should be a strong factor in the 'cracks to walls' defect (see section 6.10.7). It is pertinent, however, to comment that there is nothing conclusive at this stage about this observation, until the strength or weakness of each criterion in relation to the other four criteria is established.

6.9.1.3 Construction Factors

Tables 6.7 and 6.7b show the results of the building surveyors' responses to the scoring of construction influence on components. The five most influenced components as a result of construction are rot (dry or wet), slab failure, dampness in solid floor, water ingress and damp proofing to wall. It is noteworthy that the first three of this list, namely; rot, dampness in solid floor and damp proofing to wall are shared in common with design criterion influence. It is therefore not out of place to propose a tentative hypothesis that construction and design influences are reasonably correlated. This is not surprising, as design invariably determines construction.

The five least 'construction vulnerable' components appear to be graffiti related damage, electrical faults, broken panes, internal door damages and burst pipes. The inclusion of electrical faults in this list is interesting. This is not far fetched, as installation of electrical works is regulated by a regulatory body, and is expected to pass the required test on installation before use. Obviously, graffiti has nothing to do with the quality of construction, and therefore not surprising that it tops this list. Glazing works, internal door, and plumbing works are generally simple and straight forward activities in a dwelling and therefore operatives are least likely to make mistakes in installations.

As with the top five, the bottom five also share internal door damages, broken panes and bust pipe with design criterion. This can be attributed to the twin relationship that exists between design and construction. It is however note worthy that whilst graffiti is the lowest item under construction influence, the same is not the case in design, thus confirming that the two criteria are not completely interchangeable.

6.9.1.4 Vandalism Factors

Table 6.8 and 6.8b show the results of the building surveyors' responses to the scoring of vandalism influence on components. The five most influenced components as a result of vandalism are graffiti, damage to external door, broken pane, internal door damage and damaged fence. This is not surprising as it is expected that the items of prime importance under this criterion should be those external to the building fabric. According to Armstrong and Wilson (1973) for instance, vandalism is commonly believed to be external to the building. With internal door damage coming up in the list, the suggestions (see chapter 4) that there could be a vandal within the building itself is confirmed. This supports the notion that wilful damage on the part of the tenant or his dependent is considered to mean vandalism by the surveyors in this sample (Olubodun and Mole, 1996). Following from this finding, housing managers, in planning for maintenance work should allow for vandalism budget variance on graffiti, external door, glazing works, fencing and internal doors.

The five least 'vandalism vulnerable' components are wall tie failure, damp proof failure, cracks to walls, condensation problem and concrete slab failure. The inclusion of condensation problem on this list fails to support Olubodun and Mole's (1996) notion that wilful neglect is tantamount to vandalism. It is common knowledge that whilst there may be several factors at play in condensation, wilful neglect is far from being an unimportant factor. It is however pre-mature to draw final conclusion on the importance of vandalism in condensation until the overall strength or weakness of vandalism in relation to the other criterion is known (see section 6.11.7).

6.9.1.5 Changing standard Factors

Table 6.9 and 6.9b show the results of the building surveyors' responses to the scoring of changing standard influence on components. The five most influenced components as a result of changing standard are condensation, electrical faults, heating failure, gasleaks and defective roof structure. It is not surprising that electrical faults, heating failure and gasleaks are symbols of improvement on a dwelling. A dwelling without gas supply, heating and comprehensive rewiring work done on it, is anything but modernised. As is expected, the effect of 'modernisation' on an otherwise 'old' dwelling unit is condensation, which in this case tops the list.

The five least changing standard vulnerable components are internal door, backflow in pipes, water ingress, lifts and glazing panes. The fact that glazing panes is included in the bottom list reveals that respondents do not consider programmed work requiring wholesale reglazing or window replacement not precipitated by immediate repair needs as part of repairs or maintenance work in a true sense. This position accords with Mole and Olubodun's (1995a) position which suggested that maintenance is widened to include some aspects of programmed works of refurbishment and improvement.

6.9.2 Interpretation of Results

It can be seen from the concordance tests results in Tables 6.5b 6.6b, 6.7b, 6.8b, and 6.9b that the five coefficients of concordance are very highly significant. The low probability in all the cases associated with the observed value of W enables us to reject the null hypothesis in favour of the alternative hypothesis H_1. In essence, surveyors in the study sample were in agreement in assessing the strength of each of design, construction, age, changing standard and vandalism as a causative factor for defects on building components.

Given this general agreement, the study proceeded to establish the level of importance of the five criteria, and of defects caused on building components. In seeking to achieve the former objective, it was intended to establish from the combined scoring of the surveyors which of the causative factors presented was held to be the most influential, which the second, which the third, etc. on overall defects/repair generation. On first hand examination, it may be thought that this could be achieved by simply summing up the scores on each factor column by the 45 building surveyors as suggested by Mole and Olubodun (1995b). To do so will be fatuous as their model for assessing criteria's importance presumes that all components are of equal weights of occurrence. This is certainly not the case as evident by respondents' ranking in response to question No. 5 (which asked respondents to rank all the 28 component according to the frequency of defect on a general basis without isolating any one criterion). As Table 6.10 shows, the building surveyors are significantly agreed in their judgement.

Tables 6.5, 6.6, 6.7, 6.8 and 6.9 reveal that the impact of each of the criteria, namely; design, age, construction, changing standard and vandalism on a dwelling building can be assessed on individual components rather than on the building as a whole. Furthermore, the impact of individual criterion can be evaluated on identifiable components on which such impact is strongest. Therefore, given certain defects in a component, it becomes easier for building surveyors to begin the identification process for the cause by the elimination of unlikely causes. For example, as in Table 6.7, damp proof failure to wall is most likely to have its cause in bad construction which may have been precipitated by damp proof course bridging. Similarly, damp floor problem (see Tables 6.5 and 6.7) should require that design and construction would be the most likely candidates for examination in order to identify the cause of such defect.

Table 6.10 shows the generalised consensual ordering of component defects. In assessing overall maintenance requirements, building surveyors are generally of the opinion that the five most important component defects are condensation, defective damp proofing, water ingress, damp floors and broken panes.

The five least important component defects are soil pipe backflow, lift room repair, external storey panels, graffiti and balcony concrete repairs. These components seem to be restricted to certain class of housing construction typology rather than being common to all typologies. Hence the need to proceed with further analysis to detect any underlying patterns in component defects and causative criteria.

6.10 Relationships Between the Five Defect Criteria

1. **Null Hypothesis:** Technical knowledge possessed by building surveyors, of the building is the most important ingredient in tracking down maintenance in housing properties.

Alternative Hypothesis: Technical knowledge possessed by building surveyors, of the building is not the most important ingredient in tracking down maintenance in housing properties.

2. **Null Hypothesis:** Of the five factors identified, none is more important than others for the prediction of housing maintenance requirements.

Alternative Hypothesis: Of the five factors identified, some are more important than others for the prediction of housing maintenance requirements.

6.10.1 Generating the data

The original data collected with the help of the questionnaire were primarily based on the Likert-type ordinal scaling method (Champion 1981; Black and Champion 1976).

In seeking to convert a lower order level data on ordinal scale to a higher order level data on interval scale, it is certain that the resulting scores follow the order of the original ordinal scores in magnitude (Reynolds, 1977). The most highly ranked attains the highest interval score (representing the frequency of defect occurrence on a given component as a result of the influence of an identified causative factor). What is not certain is the extent to which a component ranked 1 is more frequent than 2, and 2 more than 3, etc. In the final analysis, the case would be that we are arrogating constancy to the difference between succeeding scores, which to a theoretical rather than practical extent, is being corrected for by the transformation;

$100\ln(30 - Rank)$.

Various transformation techniques that can be applied to the original data have been identified by Yule and Kendall (1950). A necessary and important condition for the regression model is 'linearity'. Norusis (1990) noted that a commonly used transformation to convert an otherwise non-linear variable to a linear one is the natural logarithmic technique.

The criterion $(30 - Rank)$ corrects for scoring the most frequent at 1, the second most frequent at 2, etc. The constant 30 within the criterion was chosen to exceed the maximum score by 2 points. The choice of two was to ensure that the resulting transformation could not be zero. The multiplier, '100' is used to avoid handling figures which are numerically too small to manage, without affecting the outcome of the result either way.

The final criterion index developed from the original ranks is a form of weighted index as it recognises building components which are believed to be more frequently occurring than others in terms of defects along different lines of causation.

In the face of existing poor record keeping (Bird, 1987) in the building maintenance field, this may prove to be an important improvement on defects records, where any is available.

In practice, where records of defects are being kept as in the Direct Labour Organisation (DLO) computer system, the causes of defects are never recorded, and hence practically non-existent. The theoretical data arrived at, based upon a questionnaire research instrument can therefore be described as an inaugural theoretical technique for quantifying defect-cause phenomenon. Inasmuch as there can be said to be an independent variable, it is one whose existence must be inferred from whatever patterns may exist in the resultant data. It is the raison d'être of the transformation technique to make such inference credible. This construct serves a similar purpose to Spedding *et al*'s (1995) priority index which they defined as a method of ranking anticipated maintenance and repair. The essence of their ranking being that the 'application of common standards would reduce the subjective element that has featured so largely in maintenance decisions'.

It is important to compare this theoretical model with actual data when the culture of defect-cause data recording is in place. However, this will require that the surveyor's training and practice guidelines specify that systematic diagnosis and prognosis of defects are given equal priority.

6.10.2 Weakness of the technique

There is a fundamental dubiety belying the manipulated sample data, which in this case are made up of building elements as cases. It is impossible to attribute independence to the data set of each variable much in the same way that 'observations from each member of a class that share certain features in common' are not truly independent. However, such artificiality is an unavoidable characteristic of statistical control in contrast to true experimental control (Kinnear and Gray, 1994).

6.10.3 The Dependent and Independent Variables.

The independent variables in the analysis that follows are age, design, construction (CONSTRUT), standard (STANDARD1) and vandalism (VANDAL1). The value on each variable was obtained by developing ranks in each of Tables 6.5, 6.6, 6.7, 6.8 and 6.9, so that the maximum rank corresponded with the total number of building components included in the survey. This value was then converted to interval scale by the transformation $100\ln(30 - Rank)$ (section 6.10.1).

The dependent variable is labelled GENRANK1, and it measures the overall intensity of defects across components as perceived by building surveyors within the sample.

6.10.4 Discussion of the individual regressor and its significance

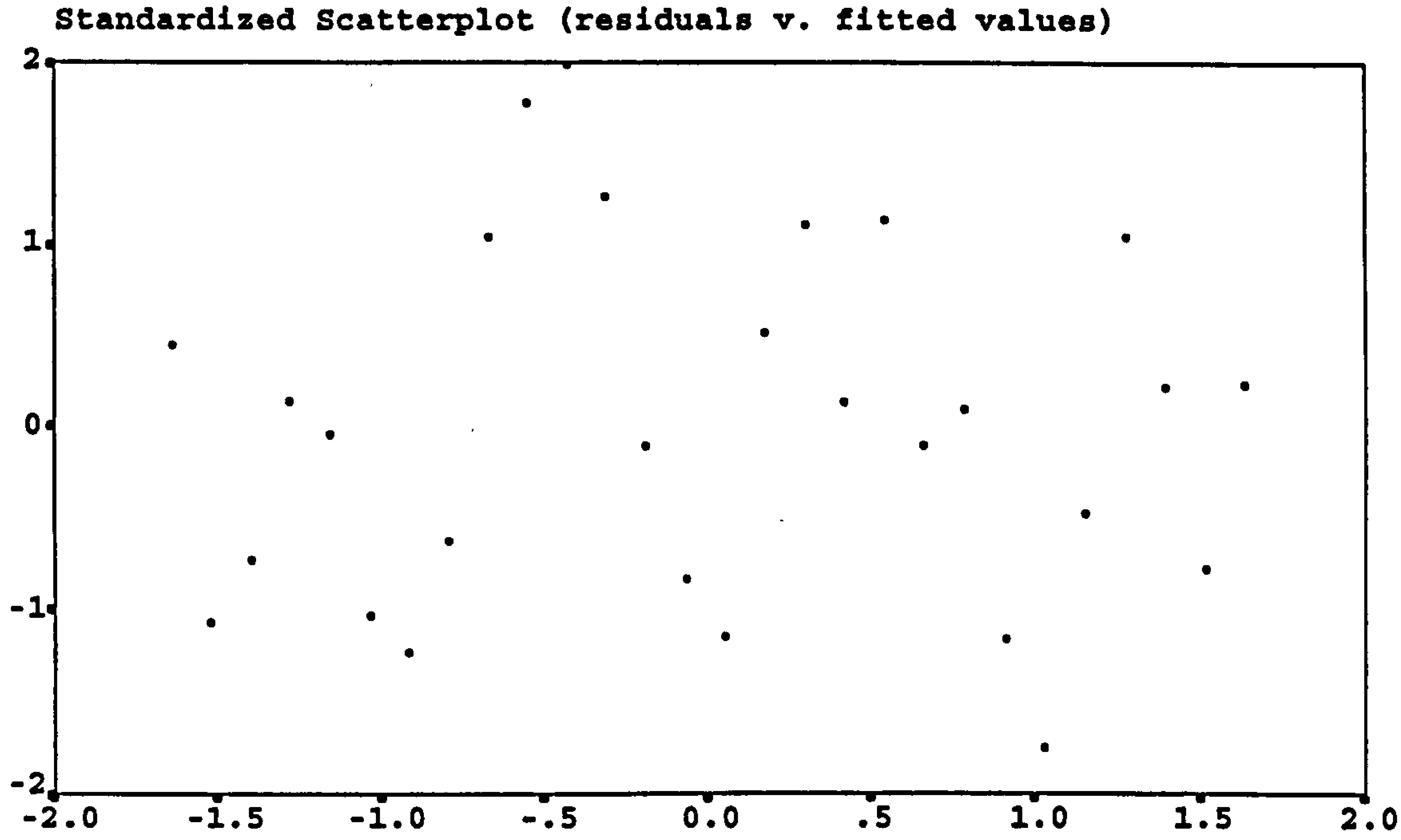
The result of the regression of design, age, standard, construction and vandalism on the dependent variable, overall intensity of defects across selected components (GENRANK1) is shown in Table 6.11. The result shows that the F-values are significant at 10% level of significance for design, standard and construction. Thus confirming that these three variables are significant sources of variation in the dependent variable, and that the relationship is linear to a statistically significant level. It is noteworthy that the t-values for each of the three significant linearly related variables exceed unity, i.e. $T > 1$, whereas corresponding values for the two insignificant variables are less than unity. This is suggestive of a tentative non-linear relationship between age of building and maintenance requirements, and vandalism and maintenance requirements. It is however interesting to observe that the t-value for vandalism is negative. This indicates that maintenance requirement has an inverse relationship with level of vandalism on a dwelling. This is contrary to expectation and it is further discussed in sections 6.10.7 and 8.7.3

Table 6.11: Level of criterion significance

Individual regressor	Level of significance
Design	at 2%
Age	not significant
Standard	at 7%
Construction	at 1%
Vandalism	not significant

Diagnosis

1. Heteroscedasticity



There is no systematic trend in the plot. Therefore, heteroscedasticity is not a problem.

Cook's Distance for 5 worst cases

.09164

.08954

.06491

.13457

.08188

There is no unduly influential case.

Figure 6.3: Standardised Scatterplot (Residuals v. Fitted Values)

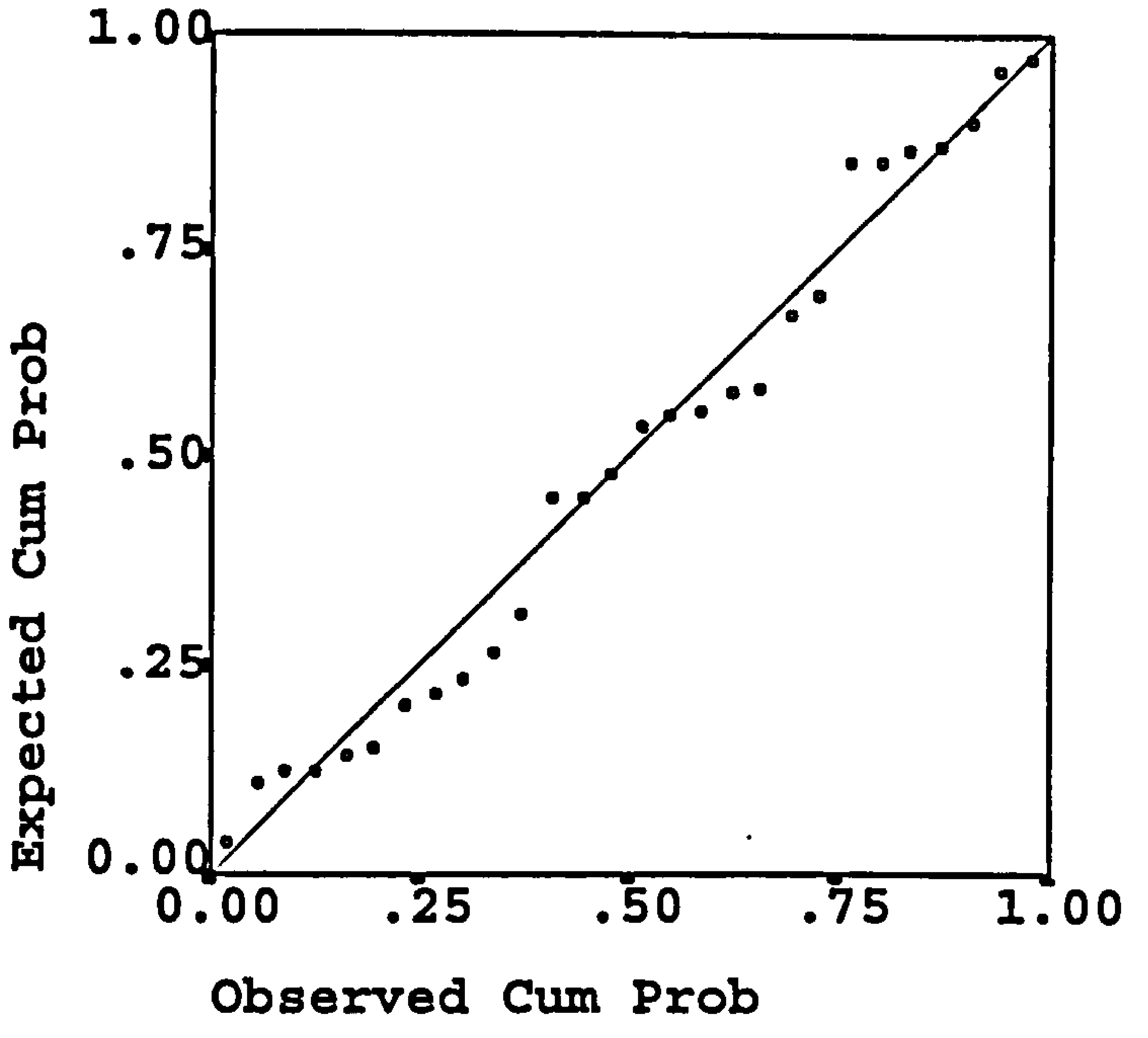


Figure 6.4: Analysis of Residuals: Normal Probability Plot

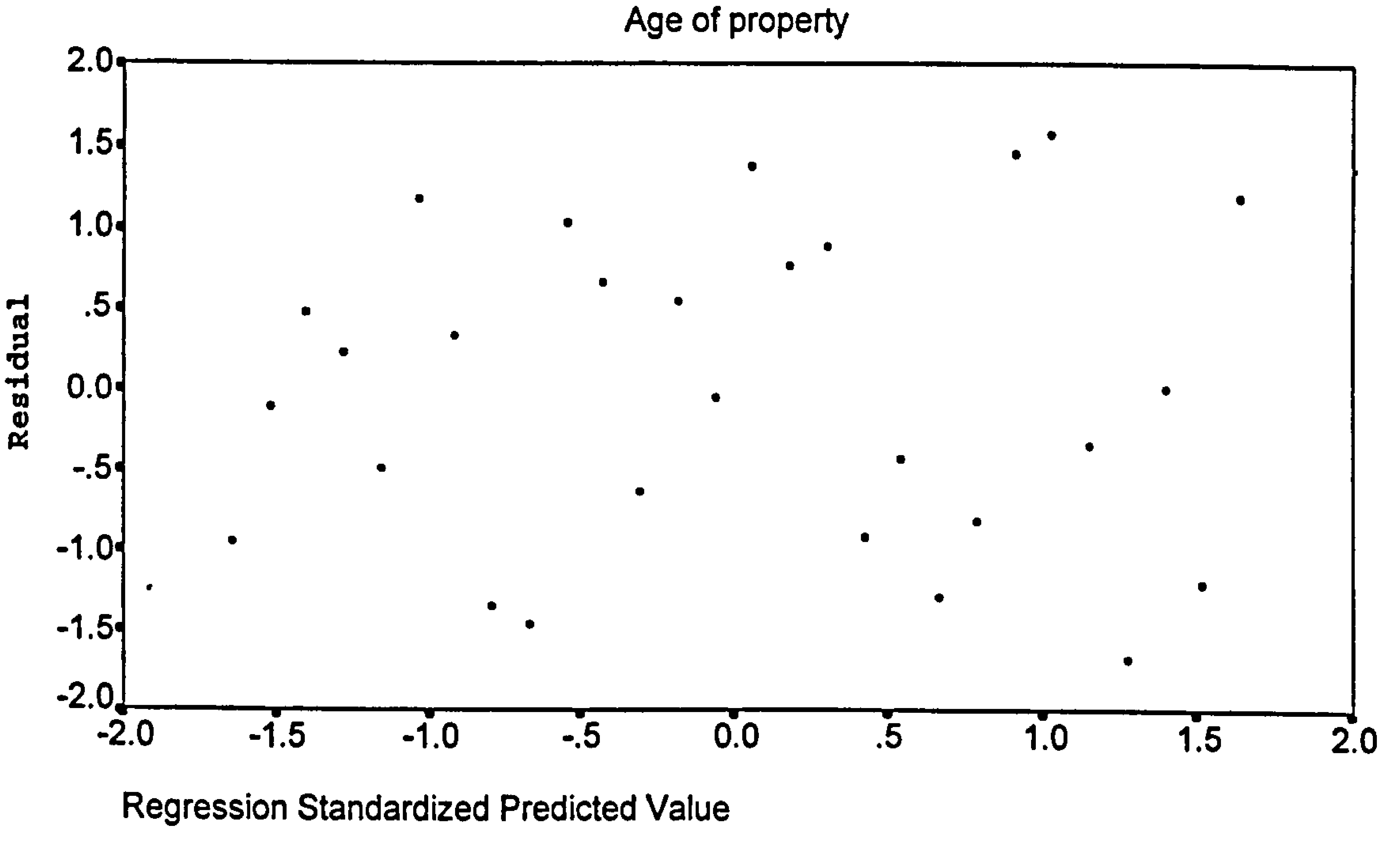


Figure 6.5: Plot of Residuals against Age of property

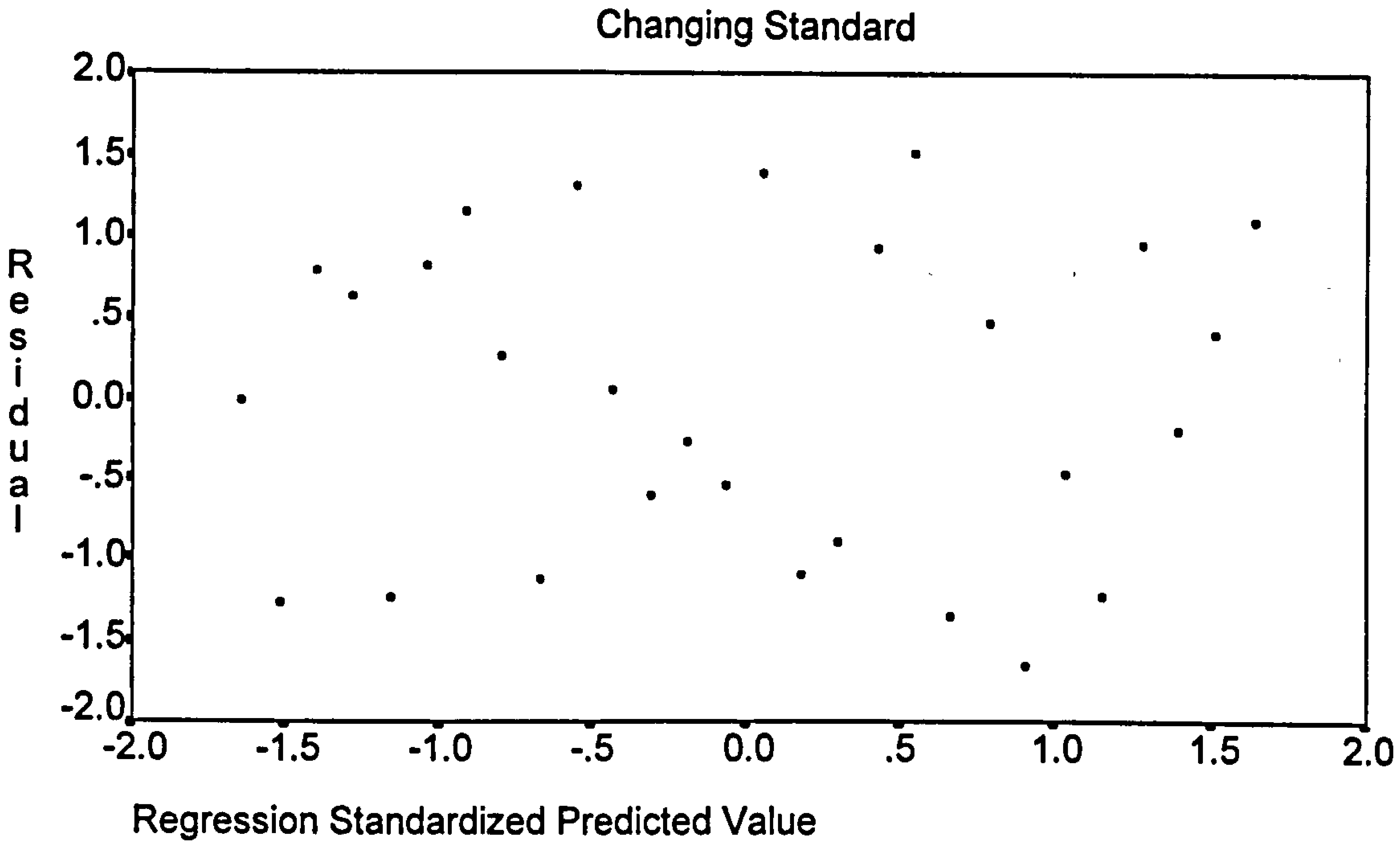


Figure 6.6: Plot of Residuals against Changing Standard

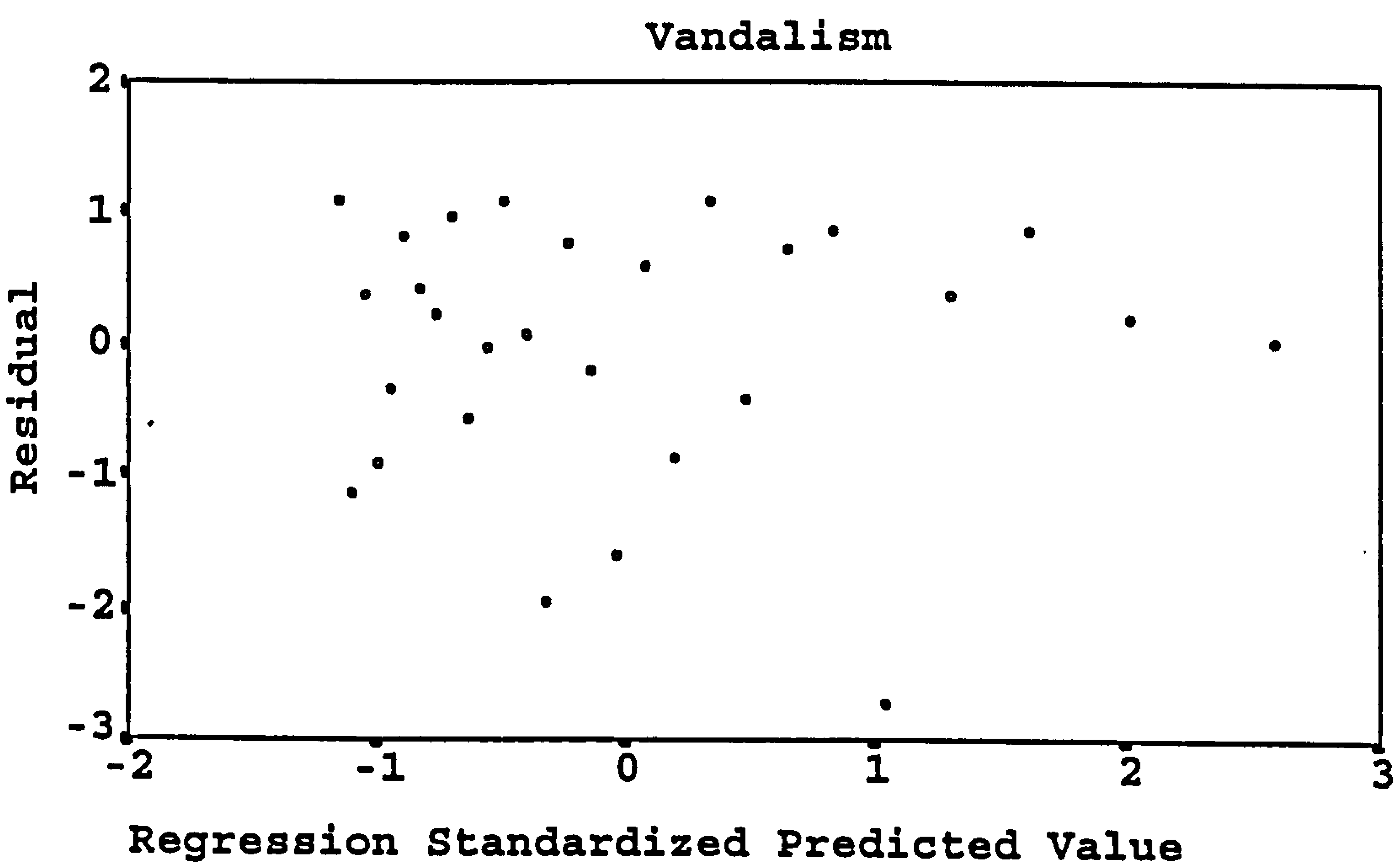


figure 6.7: Plot of Residuals against vandalism

6.10.5 Residuals Plotting

Figures 6.3 to 6.7 indicate the plotting of the standardized residual from the regression analysis against the predictor variables (age, design, construction, standard and vandalism, and dependent variable (overall intensity of defects across components). If the assumptions of linearity and heteroscedasticity (homogeneity of variance) hold for the data, it should show no pattern of relationship between the predicted and residual values. Visual inspection of the figures shows that there is no pattern exhibited in the plot of the residual values against the predicted values. Except for vandalism which reveals that the variance of the residuals may decrease with increasing vandalism measure. This confirms that the assumption of linearity and heteroscedasticity have been met.

6.10.6 Normal Probability

The normal probability plot in Figure 6.4 shows the standardised residuals on the vertical axis and the expected value (if the residuals were normally distributed) on the horizontal axis. Simply put, normality is determined by how well the residuals lie along a straight line along the diagonal.

It is expected that the residuals lie on a perfect straight line if the relationship between the GENRANK1 (overall intensity of defect across components) and each of the five independent variables DESIGN1(design), VANDAL1 (vandalism), STANDRD1 (changing standard), CONSTRT1 (construction) and AGE1 (age) is basically a straight one. In each of the five cases, the condition of perfect normality is not confirmed. However, the departure from normality is not profound as to violate normality condition (after Kinnear and Gray, 1994).

An examination of the F ratios for the five independent variables shows that only DESIGN1, CONSTRT1 and STANDRD1 are significantly linear with GENRANK1. However it is expected that each of the five variables would bear an influence to a lesser or greater extent on the overall intensity of defect across components

(GENRANK1). Besides, it not expected that these five variables are any close to being an exhaustive list of possible variables affecting the overall conditions of components, hence, 'R' is not expected to be disproportionately high.

Table 6.12: Combined model equation

```
                 * * * *   M U L T I P L E   R E G R E S S I O N   * *
* *

Listwise Deletion of Missing Data

Equation Number 1    Dependent Variable..   GENRANK1   Overall rank
among surveyo

Block Number  1.  Method:  Enter
   DESIGN   AGE      STANDARD CONSTRUT VANDAL


Variable(s) Entered on Step Number
   1..     VANDAL    ranking of mean score on vandalism
   2..     AGE       ranking of mean scores on age
   3..     STANDARD  ranking of mean scores on changing stand
   4..     CONSTRUT  ranking of mean score on construction
   5..     DESIGN    ranking of mean scores on design


Multiple R           .56453
R Square             .31869
Adjusted R Square    .26385
Standard Error      7.52195

Analysis of Variance
                    DF      Sum of Squares      Mean Square
Regression           5           582.24726        116.44945
Residual            22          1244.75274         56.57967

F =       4.05815       Signif F =  .0497
```

----------------- Variables in the Equation -----------------

Variable	B	SE B	Beta	T	Sig T
DESIGN	.392164	.384574	.392164	1.020	.3189
AGE	.045689	.177068	.045689	.258	.7988
STANDARD	.141392	.182958	.141392	.773	.4479
CONSTRUT	.426800	.377790	.427263	1.130	.2708
VANDAL	.460601	.286979	.460601	1.605	.1028
(Constant)	-6.751118	8.810622		-1.766	.0517

6.10.7 Results and Analysis of the combined regression equation

Parameter estimates of the partial maintenance requirement model are provided in Table 6.12 above using the transformed data as in (section 6.10.1) above. The table which is a computer print-out based on SPSS-Windows statistical package shows all the relevant statistics connected with the equation.

The model in Table 6.12 is statistically good at 95% level of significance (F-value = 4.0502), thereby enabling us to reject the null hypothesis and to conclude that a linear relationship of 32% explanation does exist between maintenance requirements and the five variables: design, age, standard, vandalism and construction.

Hypothesis No. 1 that is "technical knowledge possessed by building surveyors, of the building is the most important ingredient in tracking down maintenance in housing" is rejected. In other words, it is confirmed that technical knowledge around these variables is insufficient in the explanation of variations in maintenance requirements. This conclusion underpins the need for further study in order to underscore other factors which come into play in maintenance requirements.

Table 6.13 summarises the unsigned beta coefficient contribution to variability in maintenance requirement, expressed in percentages. The beta signs are in parenthesis.

The standardised beta weights (column labelled Beta) indicate that changing standard is the strongest variable in maintenance requirements, with construction fault second, design third, vandalism fourth, and age fifth. On the strength of this result, hypothesis 2 is not supported, and we therefore reject the null hypothesis in favour of the alternative hypothesis. That is to say, of the five factors identified, some are more useful than others in prediction of housing maintenance requirements.

Since the equation is log-linear, the standard error of the estimates implies an average within-sample prediction error of 13.4 per cent.

From the regression model, clearly the identified variables included in this segment of the study only explains a significant third of the total variations in maintenance, with differing variable possessing differing influence.

Table 6.13: Absolute coefficient contribution of variables (in per cent) to variability in maintenance requirement equation.

	Design	age	standard	construction	vandalism
Maintenance requirement	21.5	5.8	38.4	22.7	11.6
	(+ve)	(+ve)	(+ve)	(+ve)	(-ve)

Changing standard has the highest beta contribution (38 per cent). This supports the importance of technological advancement and constantly evolving stricter health and safety legislation to maintenance requirements.

Construction and design are almost equally important to maintenance requirement generation with absolute beta contribution of 23 and 22 per cents respectively. This is not surprising as the two variables are difficult to divorce from each other, and will tend to occur simultaneously. It is highly probable that a faulty design will lead to faulty construction; however, a reverse hypothesis could not be maintained. It is expected that faulty construction could obtain without the design being faulty. It is therefore not surprising that construction fault ranks higher than design fault.

Age of dwelling has an unexpectedly low but positive correlation with maintenance requirements. The beta coefficient contribution is under six per cent. This tends to suggest that age is not a highly influential factor in maintenance requirement in the housing stock within the sample, at least in relative terms. In this light, it is possible to explain the unexpected low influence of age on 'cracks to wall' defect in relation to the other 21 components that precede it in importance. Because of the low contribution of age criterion in relation to the other four criteria, the position is that the differences in importance across all the components in Table 6.6 are not really as pronounced as would have been the case with corresponding tables for criteria with higher beta contribution. In any case, the inference drawn is that even the most important components on age would not rank very highly in importance when a combined ranking of components is carried out. This position is confirmed in Table 6.10 where none of the five top most items on age (as in Table 6.6) feature in the top five most important components on overall defect occurrence in Table 6.10.

Vandalism has an unexpectedly negative correlation with maintenance requirement. The beta coefficient contribution is 12%. This may have two implications: (1) that housing management team are less responsive to maintenance demands from socially deprived areas or households; and (2) that households in areas most vulnerable to vandalism tend to care less for the condition of their dwellings, thus failing to report defects as and when they occur.

Vandalism is found to be the second lowest contributor to dwelling building object defect. Given that condensation problem is one of the five least affected components on vandalism as causative factor, Olubodun and Moles' (1996) notion that wilful neglect is tantamount to vandalism proves unsupported.

The ordering of the standardised beta weights as shown in Table 6.13 is supported by consideration of the correlations between the dependent variable and each of these five regressors: the correlation between GENRANK1 and design, age, standard, construction and vandalism are 0.27, 0.13, 0.34, 0.32 and -0.14 respectively as shown in Appendix 2A.

The extremely low tolerance for four of the five variables causes one to surmise that multicollinearity is a problem with the regression model. The implications of this are twofold: (1) it is possible in the presence of multicollinearity for a set of regressors having no significant t-values to account for a significant variability in the dependent variable; or (2) that there are intercorrelations between the regressors; which, in turn, implies that defect occurrence on components are intercorrelated.

Whilst extremely low t-values are not desirable and suggest the possible existence of multicolinearity, low tolerance does not distract from the integrity of the model statistics. On the contrary, it suggests that further appraisal is required in order to fully understand the extent of interactions between the independent variables.

6.11 Conclusion

This chapter has shown that components defects can be ordered according to frequency of occurrence and hence prioritised for maintenance purpose.

Section One of the analysis demonstrates the reliability of the data upon which the analyses are based by confirming the alternative hypothesis with significant coefficient of concordance on everyone of the five criterion levels. In this segment of the analyses, it was further demonstrated that different building components respond to varying extent to different identifiable defect causing criteria, namely; age, construction, design, standard and vandalism. Thus, in order to determine the effect of any of these criteria on a dwelling building, attention should be focused on the most important components on the criteria of interest. Table 6.14 shows the important component defects which serve as strong indicators of the influence of each of the criteria, namely; age, vandalism, design, construction, and changing standard in ascending order of contribution to overall defect occurrence.

Table 6.14: Component Defect indicators for the five Defect Criteria

Defect-Cause Criteria	Indicative component
Age	Patch repair to roof; Wall ties failure; Bay, canopy and chimney flashing; Electrical faults; Balcony concrete repair
Vandalism	Removing graffiti; Damaged security door; Reglazing; Internal door repair or replacement; Fencing repair or replacement
Design	Expansion crack; Damp floor; Condensation problem; Slab and screed failure; Dry or wet rot
Construction	Dry or wet rot; Slab and screed failure; Damp floor; Water ingress; Defective damp proofing
Changing Standard	Condensation problem; Electrical faults; Heating repair or replacement of part; Gas leakage; Defective roof structure

Section Two of the analysis sought to quantify the impact of these five criteria. To this end, the analysis conclusively revealed that these five criteria are not exhaustive of all the factors at play. To the extent that these five criteria influence maintenance requirements, changing standard is the most influential at 38 per cent contribution, followed by construction and design factors at 23 and 22 per cents, followed by vandalism at 12 per cent, whilst age is least influential in terms of magnitude at only 6 per cent.

These findings support the rejection of the first two null hypotheses in favour of the alternative hypotheses. That is to say;

1. "Technical knowledge possessed by building surveyors, of the building is the most important ingredient in tracking down maintenance in housing properties" is rejected. And the alternative hypothesis that "Technical knowledge possessed by building surveyors, of the building is not the most important ingredient in tracking down maintenance in housing properties" is accepted.
2. "Of the five factors identified, none is more important than others for the prediction of housing maintenance requirements" is rejected. And the alternative hypothesis that "Of the five factors identified, some are more important than others for the prediction of housing maintenance requirements" is accepted.

From the regression analysis conducted, the explanation of variations in housing maintenance requirements of the stock being studied (as a result of the features of the building object) remains largely inconclusive because of the insignificance of four of the five t-values. This calls for a further analysis. It requires that an attempt is made to identify which (component-defects) are statistically correlated. In other words, to identify which components are distinct and are principally influenced together by common criterion. This forms the basis for the next chapter which sets out to proffer answers to Hypothesis D(i) which states that "There are no intercorrelations between the component defects, i.e. it is not plausible to localise defect causing factors to a group of components" and its alternative.

CHAPTER 7
COMPONENTS DEFECTS ANALYSIS

7.1 Objective

This chapter deals with the fourth set of hypotheses set out in chapter Six, and which emanated from questions raised about intercorrelations between defect-cause criteria in the exploration of the third set of hypothesis (see section 6.3).

The analysis set out in this chapter is intended to explore and detect underlying relationships among the defect-cause criteria namely; age, vandalism, design, construction and changing standard, following from the generally low tolerance values suggestive of the existence of intercorrelations between the criteria. Whilst these principal defect-cause criteria are identifiable and known to the sample building surveyors, the way these factors impact on component defects is through a combination of different facets of the known criteria as revealed by the existence of intercorrelations between the five criteria. A multi-variate statistical technique known as factor analysis is chosen as the method of attempting to group the variables into clusters or components with the help of SPSS/PC Factor Analysis Software programme.

7.2 Statement of Hypothesis to be tested

D(i) Null Hypothesis (H_0):There is no intercorrelations between the component defects i.e. it is not plausible to localise defect causing factors to a group of components.

D(ii) Alternative Hypothesis (H_1):There are intercorrelations between the components defects

7.3 Final Analysis of Building Surveyors Survey Data

The inclusiveness of the foregoing chapter on the regression analysis calls for further analysis to identify which component-defects are statistically correlated. This will identify which components are distinct and principally influenced together by common criteria. It is common knowledge among factor statisticians Kim and Muller (1978a and 1987b), Tabachnick and Fidell (1989) and Kinnear and Gray (1994) that the property of multicollinearity is highly undesirable for factor analysis. For the data being dealt with, it should be noted that the identifiable multicollinearity in the linear regression analysis which predicated the employment of factor analysis technique is not, in this case, a problem. This problem has been side-tracked with the use of the data resulting from Question No. 5 (which asked respondents to rank the identified 28 building components according to how frequently defects show on them) in the 'surveyor questionnaire' instrument, which sought to score each of the 28 building components as variables, and hence suited for this analysis technique.

Data reduction allows an investigator to ascertain and isolate group(s) of components (on which defects occur) that are meaningfully related. This procedure should benefit architects and surveyors who are involved in various forms of design. It should assist them in evaluating groups of components prone to certain defect causes within the ambit of the building as a technical product.

In this chapter building surveyors' understanding and decipheration of components' defects and causes are explored. The intention is to investigate how, and to what extent, each of the identified causative maintenance need factors affects the various components of a dwelling and to identify which groups of building components are statistically co-related on factorial level. The essence is to break down and identify underlying considerations (sub-factors) which govern each of the identified principal factors in the survey instrument.

Factor analysis produces an 'orderly simplification' (Burt, 1940) and is helpful in isolating sets of building components that are meaningfully related on an individual causative factor level. In doing so, professionals involved in the evaluation of building (dwelling) life cycle will be able to meaningfully evaluate the impact of 'stream of influences' at various stages of a building life on maintenance need. The fundamental assumption of the technique is that it is possible to explain complex phenomena by identifying underlying factors. In essence, the technique facilitates the identification of 'not-directly-observable' factors based on a set of observable variables.

The technique of factor analysis used is described by Kinner and Gary (1994) as data reduction technique. Data reduction, in the context of the present study, means statistical identification of groups of building components which share similar response attributes to certain 'causative phenomena' which bear upon the building fabric. According to Norusis (1985) it is used to identify a number of factors which represent the relationships among interelated variables. To describe in the words of Child (1990), 'all fields of study aspiring to scientific status endeavour to describe, to formulate generalisations and ultimately to make predictions from the data observed'. Factor analysis is a well documented technique for describing data, and it has long been accepted as a data reduction technique (Thurstone 1947; Marman 1967; Cattell and Dickman; 1962).

Starting with an array of correlation coefficients for a set of variables, the technique enables a researcher to see whether some underlying pattern of relationships exist such that the data may be re-arranged or reduced to a smaller set of components that may be taken as source variables accounting for the observed interrelations in the data as indicated with low T-values in the regression analysis of chapter Six (see Table 6.12).

The use and application of factor analysis as a statistical reduction technique hinges upon the following two theorems as enunciated by Guilford and Fruchter (1978).

Theorem 1: The variance of a variable is a composite of three component variances. These components are;

1) that contributed by one or more common factors i.e. factors which appear in more than one variable.
2) that unique to the variable itself and,
3) error variance.

The above theorem can be mathematically expressed for a given variable on all identifiable factor as follows:

$$V_t^2 = V_a^2 + V_b^2 + \ldots\ldots + V_r^2 + V_v^2 + V_{err}^2 \qquad \text{———} \qquad \text{Eqn 7.1}$$

Where V_t^2 =total variance of a variable

$V_a^2, V_b^2, \ldots\ldots, V_r^2$ =variances in common factors A, B, ..., R

V_v^2 =variance specific to the variable

V_{err}^2 =error variance

For all practical purposes, Norusis (1988) has suggested that the sum of the error variance V_{err}^2, and variance specific to the variable V_v^2 i.e.($V_{err}^2 + V_v^2$) are assumed to be uncorrelated with each other and with the common factors.

Theorem 2: The second theorem of factor analysis is that the correlation between two variables is equal to the sum of the cross product of their common-factor loadings.
In summing up the two theorems, the standardised variance of the i^{th} variable can be expressed as:

$$X_i = A_{i1}F_1 + A_{i2}F_2 + \ldots\ldots + A_{ir}F_r + \text{Standardised}(V_{err}^2 + V_v^2)$$

Where $F^{'s}$ are the common factors, the $A^{'s}$ are the constants which are used to combine the k factors, and Standardised($V_{err}^2 + Vv^2$) is described by Norusis (1988) as a unique factor. The estimate for the j^{th} common factor is obtained by the general expression;

$$F_j = \Sigma_1^r W_{ji}X_i = W_{j1}X_1 + W_{j2}X_2 + \ldots\ldots + W_{jr}X_r$$

The $W_i^{'s}$ are the factor coefficients, and 'r' is the number of variables (Norusis, 1988). Where each of the 'r' observed variables is described linearly in terms of 'r' new un-correlated components X_1, X_2, ..., X_r, each of which is, in turn defined as a linear combination of the 'r' original variables.

Kinnear and Gray (1994) have suggested that factors of factor analysis are statistical realities, but psychological fictions. This opinion is predicated by the fundamental assumption that mathematical factors represent latent variables, the nature of which can only be guessed at by examining the nature of tests.

7.4 Defect Criterion data analysis

Twenty-eight variables that relate to the components of a dwelling unit have been listed in Table 6.10. The first stage of the analysis was to produce a correlation matrix as shown in Table 7.2 based on product moment correlation coefficients. The correlation coefficients express the degree of linear relationship between the row and the columns of the matrix.

Essentially, factor analysis provides information on how many factors are necessary to achieve a reconstruction of the initial coefficient matrix that is sufficiently good to account satisfactorily for the correlations it contains.

Three important criteria must be satisfied by a credible factor analysis (after Overall and Klett, 1972; and Egbu, 1994). These are:

1) parsimony
2) orthogonality and,
3) conceptual meaningfulness.

A credible factor analysis should be parsimonious, that is the number of factor one ends up with should be considerably less than the number of variables one started with. Orthogonality requires that factors are independent, and distinguishable one from another (Norusis, 1990); and of course, each factor must be conceptually meaningful and capable of identification.

An important indicator of the strength of the relationship among variables is the partial correlation coefficient. According to Norusis (1988), if variables share common factors, the partial correlation coefficients between pairs of variables should be close to zero when the linear effects of the other variables are eliminated.

Another important validity criterion for factor analysis technique is the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This criterion compares the magnitudes of the observed correlation coefficients to the magnitude of the partial correlation coefficients. Kaiser (1974) and Kinnear and Gray (1994) suggested that a KMO value below 0.5 should be considered as miserable and therefore unacceptable for the purpose of this technique. Kline (1987) also posited that it is fundamental to the technique for the number of subjects (respondents) to exceed the number of variables (building components).

7.5 Characteristics of the sample data and factor extraction

In this study, the number of respondents (surveyors) is 45, and the number of variables i.e. building components is 28. This makes for a satisfactory data base for factor analysis in line with Kline's (1987) suggestion. The value of the overall KMO statistic for the sample is 0.66177, which is reasonably above Kaiser's (1974), and Kinnear and Gray's (1994) specification of a value above 0.50, hence, we can comfortably proceed with the factor analysis.

Table 7.1 contains the initial statistics for each factor as it displays some of the salient properties of the technique. Each factor represents independent patterns of relationships in the data, with preceding factors showing more significance to the succeeding one. The eigen values as shown are equal to the sum of the squared factor loadings. The components with an eigen value exceeding 1.00 are considered significant and therefore subject to further analysis.

It is useful to explain what each column of Table 7.1 represents. The first column identifies each of the 28 variables, whilst the second column labelled communality gives the proportion of variance accounted for by the common factors, which, as expected, in this case, is 1 for all the variables. The third column labelled factor identifies all the possible factors which normally equals the total number of variables. The fourth column labelled eigen value gives the total variance explained by each factor. The fifth column contains the percentage of the total variance attributable to each factor. The sixth column gives the cumulative percentage, indicating the percentage of variance attributable to that factor and those that precede it in the table.

A cursory look at the table shows that factor1 which has a variance of 4.448 accounts for 15.9% of the total variance of the 28 factors. Similarly, 77.3% of the total variance is attributable to factors 1 - 9 (inclusive).

Several procedures have been advanced for factor extraction in order to determine the number of factors to use in the model (Norusis, 1990). One popular criterion suggests that the eigen value for a factor must exceed 1.00 before the factor can be considered significant and subject to factor analysis (Goddard and Kirby, 1976).

Figure 7.1 is a plot of the total variance associated with each factor, commonly referred to as a scree plot. The name derives from its semblance to the rubble that forms at the foot of a rock slope of a mountain (Cattel, 1966).

Experimental evidence shows that the gradual trailing off of the slope begins at the kth factor, where k is the true number of factors (Norusis, 1990). It will be seen from the scree plot that at factor 9, there is a break in the steady decreasing slope. A nine factor model is therefore appropriate.

Having extracted and ascertained the appropriate factor model, the next step is to judge how well the nine factor model describes the original 28 variables.

Table 7.1: Data Characteristics for the Analysis

Analysis number 1   Replacement of missing values with the mean

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .66177

Bartlett Test of Sphericity = 831.58087, Significance = .00000

Extraction 1 for analysis 1, Principal Components Analysis (PC)

Initial Statistics:

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
DAMPROF	1.00000	*	1	4.44843	15.9	15.9
DEFRUF	1.00000	*	2	3.66190	13.1	29.0
RUT	1.00000	*	3	3.17307	11.3	40.3
WATING	1.00000	*	4	2.46367	8.8	49.1
BUST	1.00000	*	5	2.17319	7.8	56.9
REGLAZE	1.00000	*	6	1.81386	6.5	63.3
PACHRF	1.00000	*	7	1.53282	5.5	68.8
DAMGOOD	1.00000	*	8	1.23678	4.4	73.2
FLASH	1.00000	*	9	1.14402	4.1	77.3
ELECFOT	1.00000	*	10	.97814	3.5	80.8
GASLEAK	1.00000	*	11	.81749	2.9	83.7
CODENSE	1.00000	*	12	.69933	2.5	86.2
XDOOR	1.00000	*	13	.60855	2.2	88.4
FENCE	1.00000	*	14	.50798	1.8	90.2
BKDRAIN	1.00000	*	15	.48782	1.7	92.0
GRAFIT	1.00000	*	16	.41673	1.5	93.4
HEATING	1.00000	*	17	.34133	1.2	94.7
IDOOR	1.00000	*	18	.31674	1.1	95.8
SSTACK	1.00000	*	19	.25723	.9	96.7
CONCRPR	1.00000	*	20	.22757	.8	97.5
LIFTRM	1.00000	*	21	.21791	.8	98.3
XPANEL	1.00000	*	22	.14016	.5	98.8
BKFLOW	1.00000	*	23	.11742	.4	99.2
XCRACK	1.00000	*	24	.07530	.3	99.5
SPALBK	1.00000	*	25	.06603	.2	99.7
WLTIES	1.00000	*	26	.05342	.2	99.9
SLAB	1.00000	*	27	.01805	.1	100.0
DPFLR	1.00000	*	28	.00508	.0	100.0

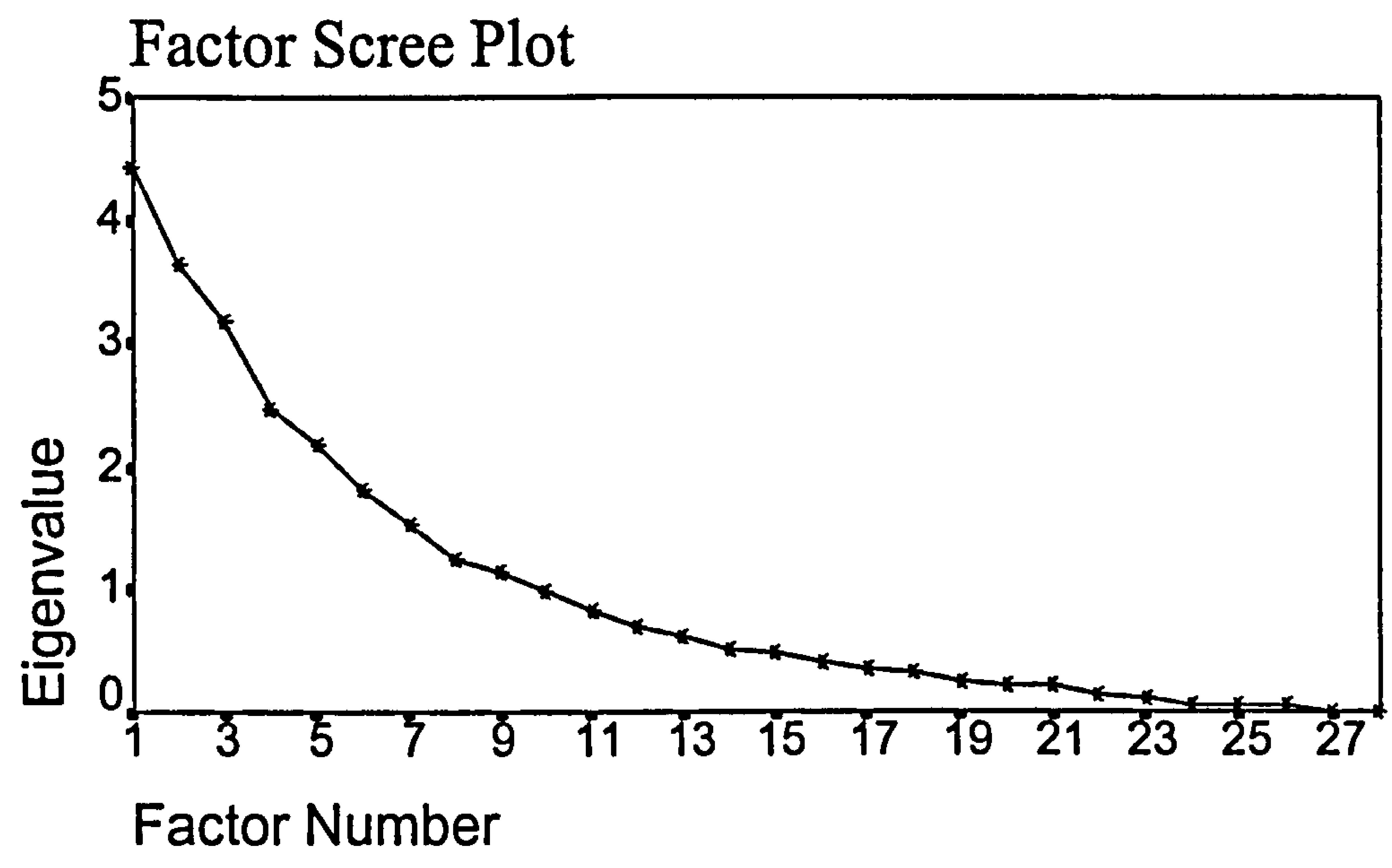


Figure 7.1: Factor Scree Plot

The first output from the principal component analysis is shown in Table 7.2. This is labelled factor matrix as the unrotated matrix which displays the correlation coefficients of each variable against an undefinable cluster of factors. As can be seen from the table, not all of the correlation coefficients have been shown as coefficients below 0.50 have been omitted from the matrix, so as to make the most important factor loadings more conspicuous. The nine principal components represent nine independent patterns of relationship in the data and together account for 77.3% of the total variance attributed to the 28 variables.

VARIABLES	FACTORS								
	1	2	3	4	5	6	7	8	9
DAMPROF	.62866								
DEFRUF									
RUT	.66110								
WATING									
BUST	-.63011	-.55860							
REGLAZE	-.64673								
PACHRF		.62721							
DAMGOOD	-.57193								
FLASH	.56134								
ELECFOT	-.60779								
GASLEAK		-.59148					.56349		
CONDENSE		.67326							
XDOOR									
FENCE									
BKDRAIN							-.53002		
GRAFIT					.58347				
HEATING			-.56640						
IDOOR									
SSTACK									
CONCRPR		.60032							
LIFTRM									
XPANEL			.61294						
BKFLOW				.57294					
XCRACK			.67767						
SPALBK			.52085						
WLTIES	.54645					-.52951			
SLAB									
DPFLR				-.59635					

Table 7.2: Building Component Defects - Principal Component Analysis (Unrotated Matrix)

7.6 Component Analysis of the Extracted Factors

Having extracted and ascertained the appropriate factors, the next step is to assess how well the nine factors explain the variations in the original 28 variables. This is achieved by a technique referred to as the principal component analysis. Table 7.3 shows the results of principal component analysis and the communalities and factor statistics after the significant factors have been extracted. The proportion of variance explained by the nine common factors is referred to as communality of the variable.

Communalities can range from 0 to 1, with 0 indicating that the common factors explain none of the variance, and 1 indicating that all the variance is explained by the common factors. The unexplained variance by the nine common factors can therefore be attributed to the unique factor. For example, 88% of the variance in PACHRF is accounted for, whereas only about 51% of the variance in SSTACK is accounted for.

7.7 Identification of the Significant Component Defects on the Factors

So far, it has been demonstrated with the help of the factor matrix, the relationships between the factors and the individual variables. However, it is still possible to minimise the number of factors on which variables have high loading, and thereby making the relationships between factors and variables conceptually meaningful. Whilst the unrotated principal components successfully define the general pattern of relationships in the data, it is possible to rotate the principal components so that they delineate any distinct clusters of relationships.

The final stage in the principal component analysis was to apply the Varimax Orthogonal Rotation of component technique in order to simplify the rows in the factor matrix. The axes of the components are rotated so as to maximise the variance of the squared loading in each column. 'To avoid bias against the contribution of the less prominent component, each variable is weighted equally for the purposes of rotation' (Traynor, 1978). The objecive of rotation is always to achieve final component loadings which maximises the variance of the squared loading in each column.

The varimax rotated matrix is shown in Table 7.4. The varimax rotation attempts to minimise the number of variables that have high loadings on a factor. Thus enhancing the interpretability of the factors.

The matrix is interpreted in section 7.7 and the significance level for the variables is put at 25% of the variance involved in a pattern. This means that a loading of 0.50 squared and multiplied by 100. Therefore, only loadings which exceed the absolute value of 0.50 are indicated in the table, with lower loadings automatically omitted by the SPSS as instructed. This ensures that the loadings for variables are only those that are substantially high, and significantly different from zero.

Table 7.3: Statistics of the Extracted Factors

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
DAMPROF	.74110	*	1	4.44843	15.9	15.9
DEFRUF	.64905	*	2	3.66190	13.1	29.0
RUT	.68294	*	3	3.17307	11.3	40.3
WATING	.88567	*	4	2.46367	8.8	49.1
BUST	.77587	*	5	2.17319	7.8	56.9
REGLAZE	.63926	*	6	1.81386	6.5	63.3
PACHRF	.88178	*	7	1.53282	5.5	68.8
DAMGOOD	.81046	*	8	1.23678	4.4	73.2
FLASH	.71933	*	9	1.14402	4.1	77.3
ELECFOT	.78015	*				
GASLEAK	.80433	*				
CODENSE	.86689	*				
XDOOR	.79851	*				
FENCE	.72994	*				
BKDRAIN	.72773	*				
GRAFIT	.76992	*				
HEATING	.81223	*				
IDOOR	.78445	*				
SSTACK	.50753	*				
CONCRPR	.82921	*				
LIFTRM	.71713	*				
XPANEL	.84167	*				
BKFLOW	.82233	*				
XCRACK	.73617	*				
SPALBK	.82611	*				
WLTIES	.84098	*				
SLAB	.82713	*				
DPFLR	.83985	*				

Skipping rotation 1 for extraction 1 in analysis 1

VARIABLES	FACTORS								
	1	2	3	4	5	6	7	8	9
DAMPROF							.61830		
DEFRUF							.78300		
RUT							.50945		
WATING								-.91093	
BUST									
REGLAZE									
PACHRF			-.68868						
DAMGOOD					-.75647				
FLASH									
ELECFOT									
GASLEAK									
CONDENSE		-.62650	.57694						
XDOOR	.88496								
FENCE	.83450								
BKDRAIN						.54215			
GRAFIT						.69773			
HEATING				.84050					
IDOOR			.84134						
SSTACK						.59271			
CONCRPR				.51198					
LIFTRM									
XPANEL									
BKFLOW		.66125							
XCRACK									.54722
SPALBK									.88420
WLTIES					.89063				
SLAB		-.73088							
DPFLR		-.78482							

Table 7.4: Building Component Defects - Principal Component Analysis (Rotated Matrix)

7.8 Interpretation of the Factors

The information given in the rotated principal component analysis matrix is now interpreted. Essentially, the principal components indicate the number of distinct clusters of relationships. Each of the nine principal components are here reviewed in turn and given an appropriate name.

To identify the factors, an attempt is made at grouping the variables that have large loadings for the same factors as in Table 7.5 (manual shuffling of Table 7.4). For example, the first factor shows strong positive correlation with defects in external doors and fence. Thus implying that defect occurrence in external door and fence are positively correlated. Similar inferences can be drawn for factors 2 - 9, with each factor consisting of building components that are positively or negatively correlated.

It is noteworthy that seven of the 28 variables do not significantly correlate with any of the factors, namely: BUST, REGLAZE, FLASH, ELECFOT, GASLEAK, LIFTRM, and XPANEL. This suggests that among others, the bulk of their underlying factors are found in the 22.7% unexplained factors outside of the nine significant factors.

To identify the factors, it is necessary to group the variables that have large loadings for the same factors.

All the nine factors are listed below together with associated variable labels and full component names (as in Table 7.6). Factors 1 through to 9 are distinct and capable of identity. Factor 1 relate to dwelling externality and thus might be interpreted as measuring something like "dwelling external influence". The second factor is negatively correlated with condensation, concrete bed/slab failure and dampness in floor, but positively correlated with backflow. This factor describes the design integrity standard of the dwelling. All the nine factors are listed below and classified under nine different defect causative characterisations.

Table 7.5: Significant Component Defects on the Factors

Variables	F1	F2	F3	F4	F5	F6	F7	F8	F9
XDOOR	.88496								
FENCE	.83450								
CODENSE		-.62650	-.57694						
BKFLOW		.66125							
SLAB		-.73088							
DPFLR		-.78482							
PACHRF			-.68868						
IDOOR			.84134						
HEATING				.84050					
CONCRPR				.51198					
DAMGOOD					-.75647				
WLTIES					.89063				
BKDRAIN						.54215			
GRAFIT						.69773			
SSTACK						.59271			
DAMPROF							.61830		
DEFRUF							.78300		
RUT							.50945		
WATING								-.91093	
XCRACK									.54722
SPALBK									.88420
BUST									
REGLAZE									
FLASH									
ELECFOT									
GASLEAK									
LIFTRM									
XPANEL									

Table 7.6: Groupings of the Factors and the Components

Variable Labels	Building component - Defect title
Factor 1	
XDOOR	Damaged security door
FENCE	Fencing repair or replacement
Facor 2	
CODENSE	Condensation problem
BKFLOW	Soil pipe backflow
SLAB	Slab and screed failure
DPFLR	Damp floor
Factor 3	
PACHRF	Patch repair to roof
IDOOR	Internal door repair or replacement
Factor 4	
HEATING	Heating repair or replacement of part
CONCRPR	Balcony concrete repair
Factor 5	
DAMGOOD	Damaged rain water goods
WLTIES	Wall ties failure
Factor 6	
BKDRAIN	Blocked drains
GRAFIT	Grafitti
SSTACK	Soil stack (high rise)
Factor 7	
DAMPROF	Defective damp proofing
DEFRUF	Defective roof structure
RUT	Dry/Wet rot outbreak
Factor 8	
WATING	Water ingress
Factor 9	
XCRACK	Expansion crack
SPALBK	Spallled bricks

Factor 1	Dwelling external influence
Factor 2	Design integrity standard of dwelling
Factor 3	Tenant's lack of care index
Factor 4	Influence of changing and evolving standard
Factor 5	Ageing influence
Factor 6	Vandalism - Design pull effect
Factor 7	Design - construction inadequacy
Factor 8	Accidental damage restricted to building envelope
Factor 9	Dwelling orientation and soil condition

7.9 Discussion of the maintenance requirement factors based on factor analysis technique

Factor 1 - Dwelling external influence

This component accounts for 16% of the total variance and two building component-defect titles namely; damaged external door and fencing repair and replacement work are shown with significant loadings on this cluster. The higher loading is given to the defect in external door variable (XDOOR $: r = 0.8850$) and this indicates the overwhelming importance of external doors to overall maintenance profile.

The importance of external phenomenon upon the building fabric is reflected in the loadings given to one other variable related to the externals of the building; defective fences (FENCE $: r =$ 0.8345). From the primary analysis and the correlation matrix, the patch repair to roof (PACHRF) does not appear significant, yet, this is as much an external feature as the two significant variables. This leads us to infer that what bears most heavily upon this component factor has more to do with the combination of the vagaries of climatic exposure and human destructive instinct. As in roof tiles, the latter influence is to a large extent totally absent and therefore not significant.

Factor 2 - Design integrity standard of dwelling

This component absorbs 13% of the total variance with both positive and negative significant loadings.

Negative loadings on condensation (CODENSE : r = -0.6265), floor bed/slab failure (SLAB : r = -0.7309) and dampness in floor (DPFLR : r = -0.7848). This is indicative of technical aspirations which future house designs must address.

A positive loading on backflow in waste disposal plumbing units (BKFLOW : r = 0.6613) shows that backflow problems are judged by the building surveyors to be of secondary importance.

It can be inferred that this cluster measures respondents' opinions on the effectiveness of the design. The component will be called the 'Design Integrity Standard' factor and as such measures a criterion of utmost importance for the housing maintenance market. This factor must be of vital concern to both designers (architects and building surveyors), and housing managers.

Factor 3 - Tenant's lack of care index

The third component includes significant positive and negative loadings which incorporate approximately 11% of the total variance. Whilst condensation and defects requiring patching up of roof are both negative (CODENSE : r = -0.5769; PATCHRF : r = -0.6887), internal door is positively loaded (IDOOR : r = 0.8413). Since condensation variable is again given a negative loading as with PATCHRF, it implies that respondents generally opined that condensation problem is a primary measure of tenant's care or lack of care in the same way as the overall condition of the roof covering.

Whilst PATCHRF and CODENSE are both negatively loaded, it should be appreciated that the two variables relate to the same factor from different perspectives. The level of condensation measures tenant's 'disposable care' towards the dwelling whilst roof defects requiring patch up measures his 'inhibitive concern' for the dwelling. In both cases, the tenant's readiness to exercise positive care on the dwelling is being measured. The high positive loading on IDOOR places this variable as prime indicator of "Tenant's Care Index" for the dwelling.

The positive loading for internal door shows that this variable is averse to the other two significant variables on this factor component. It would be reasonable to infer that this variable measures tenant's 'prohibitive care' for the dwelling.

Factor 4 - Influence of changing and evolving standard

The fourth component absorbs 9% of the total variance and two variables are shown with significant loadings on this pattern. The higher loading is given to the defects in heating installations (HEATING : $r =$ 0.8405), and the loading given to defects requiring concrete repairs is (CONCRPR : $r =$ 0.5120).

Each of these two variables relate to changes in standards from different focal points. On one hand, HEATING relates to changes in the maintenance need profile occasioned by improved heating systems in comparison with erstwhile 'coal fire place'. On the other hand, CONCRPR relates to the bespoke flirting with concrete form of construction of the 1960s (Wyatt, 1980).

The component measures the influence of standard on defects generation and can be identified as "Changing and Evolving Standard".

Factor 5 - Ageing influence

Component No. 5 describes the Ageing Influence factor on maintenance requirements. This component includes two significant loadings either of which is positive and negative, and incorporates approximately eight per cent of the total variance.

The positive loading is on the wall ties defects (WLTIES : $r =$ 0.8906) which displays to a large extent the influence of age since installation. The negative loading is on defective rain water goods (DAMGOOD : $r =$ -0.6887) which indicates that it is seen as a secondary measure of ageing. That is to say, the variable can be used to monitor the effect of age when the other variable is not applicable to a particular building.

Factor 6 - Vandalism - Design Pull effect

This component accounts for seven per cent of the total variance and three variables are shown with significant loadings on this pattern. The highest loading is given to Graffiti (GRAFIT : r = 0.6977) which indicates the superiority of this variable on the factor component.

The importance of systematic but conscious and insidious destruction of the built form is reflected in the loading given to the one other variable related to what may be described as vandalism, soil stack failure (SSTACK : r = 0.5927).

Blocked drains was also given a positive loading (BKDRAIN : r = 0.5422). Judging from the concordance tests of the preceding chapter, it was observed that this defect item ranks highest on age and second highest on vandalism. Component No. 6 therefore represents the significant effects of vandalism - design pull effect as enunciated by (Cosby, 1985).

Factor 7 - Design - construction inadequacy

The seventh component includes significant positive loadings which incorporate approximately six per cent of the total variance.

The largest loading is on defective roof structure variable (DEFRUF : r = 0.7830) which portrays the cause of failure in the structural integrity of roofs as against cosmetic failure. The importance of timber as building material is reflected in the loading given to dry or wet rot outbreak which is related to the same material (RUT : r = 0.5095). It would have been expected that since rot problems have more to do with cosmetic rather than structural deficiencies the two variables should not co-relate. However, the existence of structural failure inevitably leads to cosmetic failure in the medium or long term.

Damp proof course failure, which inevitably leads to rising damp was also given a moderately high positive loading (DAMPROF : r = 0.6183). This variable is vitally related to dry or wet rot outbreak.

The three variables that are included in this factor component are most interestingly related. Rot outbreaks in most house types where they occur are common in either loft or sub-floor. The two locations are associated with each of the two variables which inter-link RUT, i.e. DEFRUF and DAMPROF.

It would be reasonable to infer that this component pattern measures the efficiency of both design and construction.

Factor 8 - Accidental damage

This component accounts for about four per cent of the total variance. It shows one significant highly negative loading on the variable for water ingress, (WATING : -0.9109). The component apparently measures the tenant's propensity to accidental damage on the building envelope. The negative sign of this loading suggests that accidental damage to property would least likely result in either of penetrating damp or flooding. That is to say, the factor component and the variable on which the factor is significant are almost diametrically averse to each other (inverse relationship exists between the two).

Because the factor informs of what it does not measure rather than measure, it is left to conjecture as to the relevance of this component to overall framework of defect generation and subsequent strategy for damage limitation. This result underpins the generally prompt response that is often accorded any reports of penetrating water or flooding as it would least likely be caused by user's neglect.

Factor 9 - Dwelling orientation and soil condition

Component No. 9 is the last of the important components and includes four per cent of the total variance. The first nine components have accounted for about 77% of the total variance and therefore the 19 remaining components would be relatively insignificant and together account for less than 23% of the variance.

This component shows two significant positive loadings on the variables for spalled bricks (SPALBK : $r =$ 0.5472) and cracks to walls (XCRACK : $r =$ 0.8842). The component apparently measures what might be described as the building's reaction to the vagaries of its situation. The two variables SPALBK and XCRACK are very similar, and therefore it is no surprise that the two variables bear the effect of a common pattern.

The component is named Dwelling Orientation and Soil Condition and would be important for maintenance managers when making maintenance budgets for dwellings. In essence, variance in maintenance expenditure as a result of orientation and soil condition should be reflected in the component of maintenance budget to cover spalling bricks and expansion joints.

7.10 Conclusions

The chapter has shown that in relation to internal attributes of the building, the factors at play are not simply those features commonly considered by designers, but involve the inter-play of factorial combination phenomenon, which this segment of the study has underscored.

The principal component analysis technique has allowed the data collected from building surveyors through the questionnaire instrument (Appendix 1B) to be simplified and interpreted into key component factors which influence maintenance need of a dwelling on a broad basis. Thus addressing the part of the research framework pertaining to Internal Attribute Component of the model in Figure 2.2.

From the point of view of a maintenance manager, each of the nine categories represents strategic influences, an understanding of which surveyors must acquire in order to proffer sound remedies to the defects encountered in survey of dwellings.

Through the factor analysis technique of data reduction, it has been established statistically, the correlations between components-defects. In all, defects causative influences have been grouped into a nine-factor model according to their levels of importance.

This evidence, provides a basis to reject the null hypothesis in favour of the alternative hypothesis, that is, the plausibility of localising defect causing factors to a group of components is hereby confirmed on the basis of intercorrelations which exist between component scores.

The use of the chosen statistical technique proved to be highly successful in detecting the underlying patterns and reducing the mass of data into a brief yet coherent statements. The set of component factors for housing maintenance needs gave an insight into the criteria available for those involved in determining maintenance budgets.

CHAPTER 8
MAINTENANCE - TENANT MODEL

8.1 Introduction

This chapter focuses chiefly on the impact of tenants on dwelling maintenance need, and in the process touches upon environmental and housing management impacts. The chapter deals with the methodological framework for the measurement of maintenance requirements and measurable variables that impact upon them. These entail the exploration of tenants' characteristics, housing management responsiveness, environmental stress and selected property characteristics on the sampled dwellings, and how they affect maintenance need.

The aspect of tenants' characterisation has serious and complex social and policy implications. An understudy of tenants and their characteristics may be seen to impinge upon the policy of equal opportunity. However, without the proper integration of information relating to property and the users of the dwelling, the phenomenon of housing maintenance need prediction will remain an intractable problem for housing managers.

Whilst chapters Six and Seven show the results of building surveyor's questionnaire survey, this chapter goes a step further by attempting to measure maintenance requirement.

The hypothesis which this chapter seeks to explore is that dwellings within the same estate and with similar architectural attribute in space and time will exhibit different maintenance need profile as a result of differences in tenants' characteristics. In essence, a significant proportion of the variation in maintenance requirement will have its explanation in the differences in tenants' personalities and attributes. It is expected therefore, that a housing manager will be able to predict a part of his maintenance budget accurately given certain information about his tenants. In this vein, a housing manager who discounts tenant information in the development of a maintenance strategy will not apply resources to full effect.

8.2 Research Approach and Limitation

Whilst this section of the study sets out to test the hypothesis in relation to tenants' influence, the choice of independent variables is decidedly broadened to encompass all the measurable variables inherent in the theoretical model of chapter two. In so doing, the study avoids the same limitation of which many studies into maintenance factors are guilty. (This has been extensively discussed in chapter Five).

The mediatory role of the stockholder is essentially discounted in this study - policy and budget matters are nebulous and do not lend themselves to direct measurement. They are principally dictated by political dictum and nuances which are a function of both national and international political and economic climates. From this family of variables therefore, we have included for housing management responsiveness only.

8.3 The survey

The data for this aspect of the study was obtained in two parts. The first part of the data was achieved by collecting data on repair costs for the sample dwellings from the authority's Direct Labour Organisation (DLO) system. The second part was based upon postal questionnaires which were distributed among tenants of the sample dwellings. In total, 252 completed questionnaire on each of which computer DLO records were obtainable provided quantitative data analysis. The 252 questionnaires used for this part of the study represented a response rate of about 40%.

8.4 Data characteristics for the dependent variables

8.4.1 Maintenance requirements Indices

To assess some of the dimensions of maintenance requirements among our sample dwellings, it was decided to gather data on three indices as follows:

1. Historic maintenance measure;

2. Satisfaction expressed by tenants on actual work carried out; and
3. Condition of property.

The choice of these three indices to assess maintenance requirement is (after Kearns *et al*, 1991). Each of the three indices is a proxy variable for maintenance need. Historic maintenance expenditure is an indication of maintenance demands on the management team. The level of satisfaction among tenants influences the amount of pressure on housing management for maintenance expenditure in the immediate future. The third index, i.e. condition of property measures the physical demand from the dwelling building for maintenance action. The bespoke annual condition survey conducted by the Council does not provide for holistic measurement of maintenance requirements, and therefore ill -suited for this purpose.

8.4.2 Derivation and Characteristics of Satisfaction Index Distribution

Derivation of the Satisfaction index - SATISFY1

The respondents were asked on a four-point scale, to what extent they thought they were satisfied with repair works on various building components as and when carried out in the last 5 years. Question No. 7 of the tenant's questionnaire (Appendix 1C) set out to elicit the required information. The response to this question was to be predicated by previous response to Question No. 6, which required respondents to identify components on which reports for repairs have been lodged in the same period, and the frequency of such reports. A case was therefore rejected wherever responses to corresponding components in Question Nos. 6 and 7 were found to be incongruent. Since it was neither practicable nor expected that a respondent would have made reports on all the 28 components within the time specified, the final index was based only upon relevant components. While the components that were not applicable within the five-year period were discounted.

The responses were combined into one factor. This was achieved by averaging the responses on all the relevant components for each respondent and then multiplied by 100 to avoid decimated figures, which resulted into a pseudo-interval scale factor (after Kearns *et al*, 1991). The distribution of the resultant factor obtained is shown in Figure 8.1 in the form of a histogram superimposed with a normal curve.

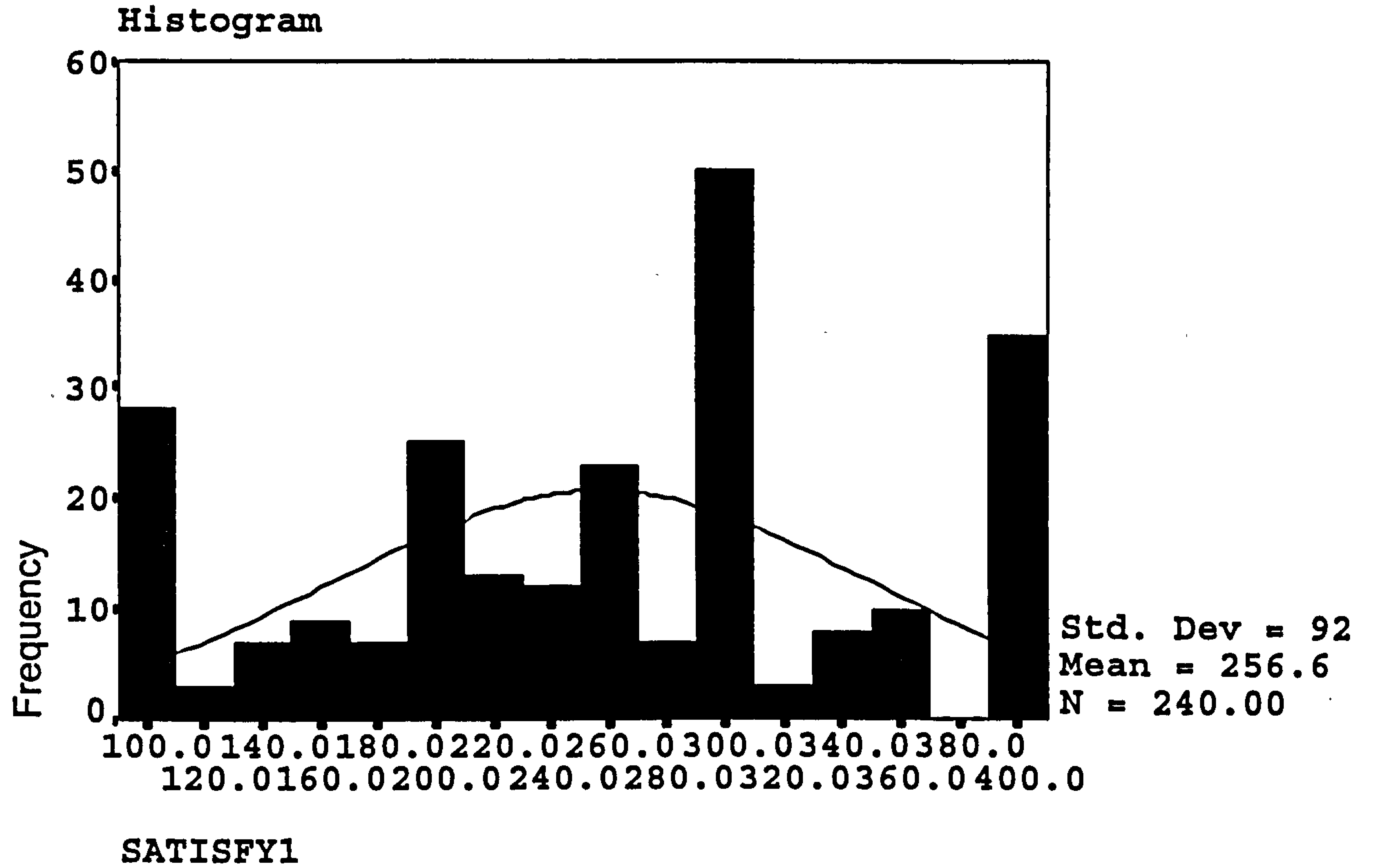


Figure 8.1: Histogram of Satisfaction

Validatory check on the index

A validatory check was carried out on the index developed by the use of the instrument in Question No.3 of Appendix 1C. This was tested by computing the correlation between SATISFY1 and HOMESAT. According to Crosby (1985) the degree of residential mobility is frequently used as indicators of satisfaction for urban and suburban areas with social and physical problems. The result of this is displayed in Table 8.1 below.

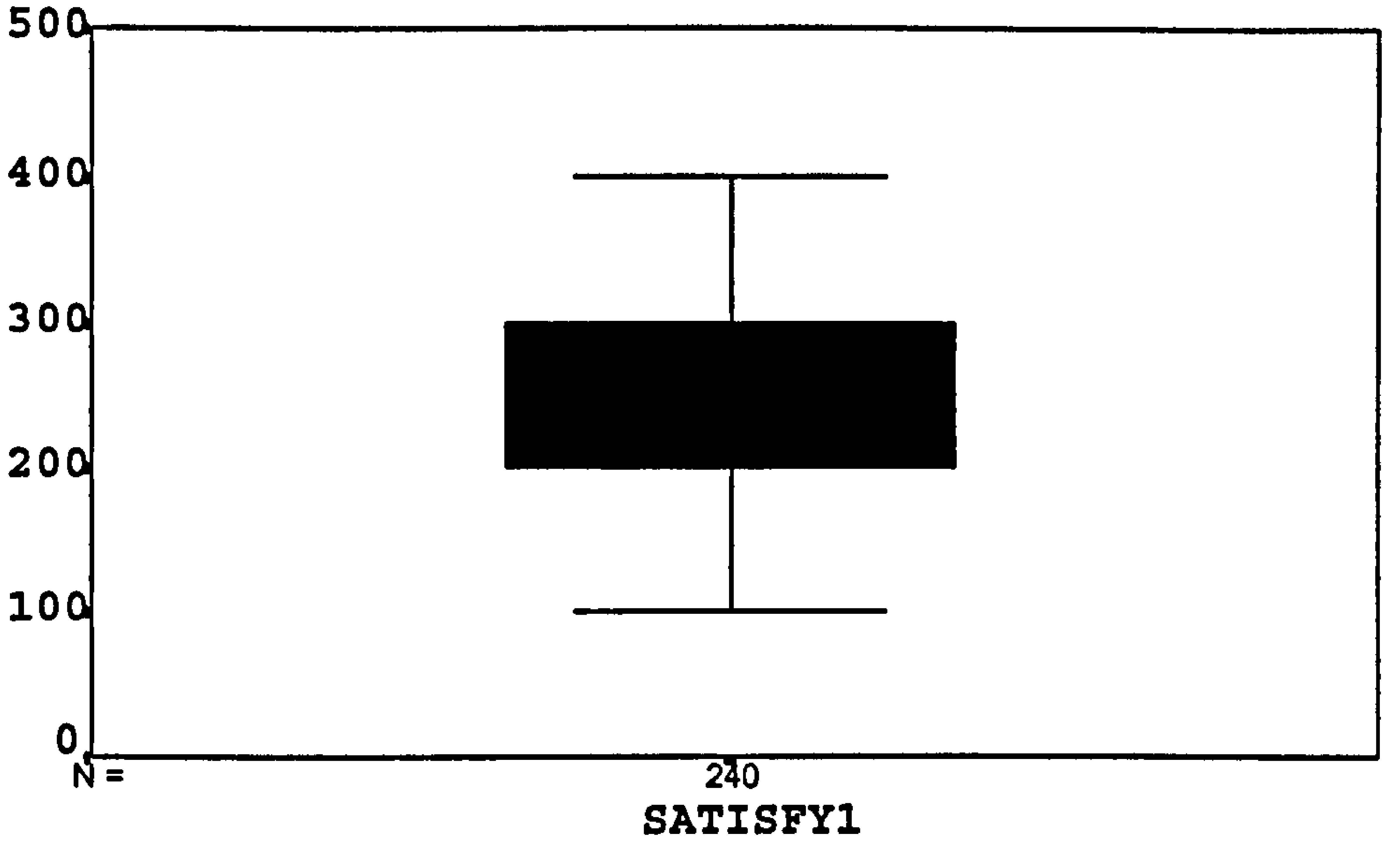
	HOMESAT	SATISFY1
HOMESAT	1.000 .	0.6182 (P = .000)
SATISFY1	0.6182 (P = .000)	1.000

Given a correlation coefficient of 62% at more than 99% level of significance, Table 8.1 shows that the two variables are significantly correlated, and hence proves the reliability of both the derived satisfaction index and the responses to corresponding questionnaire instruments.

The distribution of satisfaction index

The frequency distribution of the derived scores for the satisfaction index showed that it is short of an approximation to a normal distribution (mean =256.6280, range =100-400, SD =92.5344, skewness = -.1137, kurtosis =-.8799). See Figure 8.2.

An exploratory boxplot analysis of the data on satisfaction index criterion shows that it is not highly skewed (skewness = -.1137). However, the kurtosis of the distribution approaches unity, and hence, too platykurtic and therefore fails to sufficiently approximate a normal distribution. Incidentally, the boxplot and stem-and-leaf exploratory analyses (Figure 8.2) fail to identify any outliers or extreme values from the data. This implies that the data characteristically falls short of a normal distribution with little or no room for manoeuvré. However, given the size of our sample data, according to Norusis (1991) and Champion (1981) certain parametric tests can still apply. In this instance, given the large size of the sample, the need to use exact statistical method is not pressing, and there is no danger of violating the condition for parametric analysis.




```
SATISFY1

 Valid cases:        240.0   Missing cases:       12.0   Percent missing:      4.8


 Mean       256.6280  Std Err      5.9731  Min        100.0000  Skewness     -.1137
 Median     266.6667  Variance  8562.610  Max        400.0000  S E Skew      .1571
 5% Trim    257.3644  Std Dev     92.5344  Range      300.0000  Kurtosis     -.8799
 95% CI for Mean (244.8614, 268.3946)     IQR        100.0000  S E Kurt      .3130


 Frequency    Stem &  Leaf

    29.00        1 *  00000000000000&
     4.00        1 t  23
     9.00        1 f  4455
     7.00        1 s  667
     7.00        1 .  889
    31.00        2 *  000000000001111
    11.00        2 t  22333
    18.00        2 f  444555555
    16.00        2 s  6666677
     3.00        2 .  8&
    50.00        3 *  000000000000000000000000&
     7.00        3 t  233
     9.00        3 f  4555
     4.00        3 s  66
      .00        3 .
    35.00        4 *  00000000000000000

 Stem width:       100
 Each leaf:       2 case(s)


 & denotes fractional leaves.
```

Figure 8.2: Boxplot and stem-and-leaf for satisfaction index

8.4.3 Maintenance Costs - (MAINTCST)

The collection of the data on this variable has been discussed in chapter Two. This criterion is one of the three indices employed in assessing maintenance need requirements. An exploratory boxplot analysis of the data on historic maintenance cost criterion for maintenance requirement shows that it is highly skewed (skewness = 2.0). Whilst this feature may not pose a serious threat to further confirmatory analysis were the criterion an independent variable, the situation will change when the criterion is employed as a dependent variable, as it is in this case.

The boxplot in Figure 8.3 and stem & leaf frequency display in Table 8.2 show that there are a total of 24 outliers and extreme values in the data set which have exerted an undue influence upon the values of the mean and standard deviation (after Hartwig and Dearing, 1979). As can be seen from Tables 8.2 and 8.3 the elimination of these outliers and extreme values from the data reduces the mean from 1413 to 1014, and the standard error from 96 to 56. It is better to have statistics that describe some 90% of the original data well than having those that describe all of the data badly (Kinnear and Gray, 1994). Therefore it was decided to adopt the approach of removing the outliers and repeating the analysis with the remaining 227 subject as against the original 251 (after Kinnear and Gray, 1994). This resulted in Table 8.3.

<u>The effect of removing outliers and extreme values</u>

A comparison of Tables 8.2 and 8.3 reveals that the kurtosis (a coefficient which measures a property of the single-humped distribution) is reduced from 4.1611 (indicates a leptokurtic curve for the distribution of the data set when the outliers are included) to 0.3620. This indicates that the new data set adequately approximates a normal distribution (a vital assumption for parametric analysis technique). Thus improving the goodness of the data for subsequent analysis.

<u>Outliers</u>

Table 8.2 shows the outlier and extreme values to the bottom of the stem-and-leaf.

The outliers and extreme values (24 in number) are quite many as they represent 10 per cent of the data set, and are patterned. In other words, they do not exhibit the same random characteristics as the original data. They relate to excessively high maintenance expenditures over the time period. The elimination of these atypical scores has improved the suitability of the

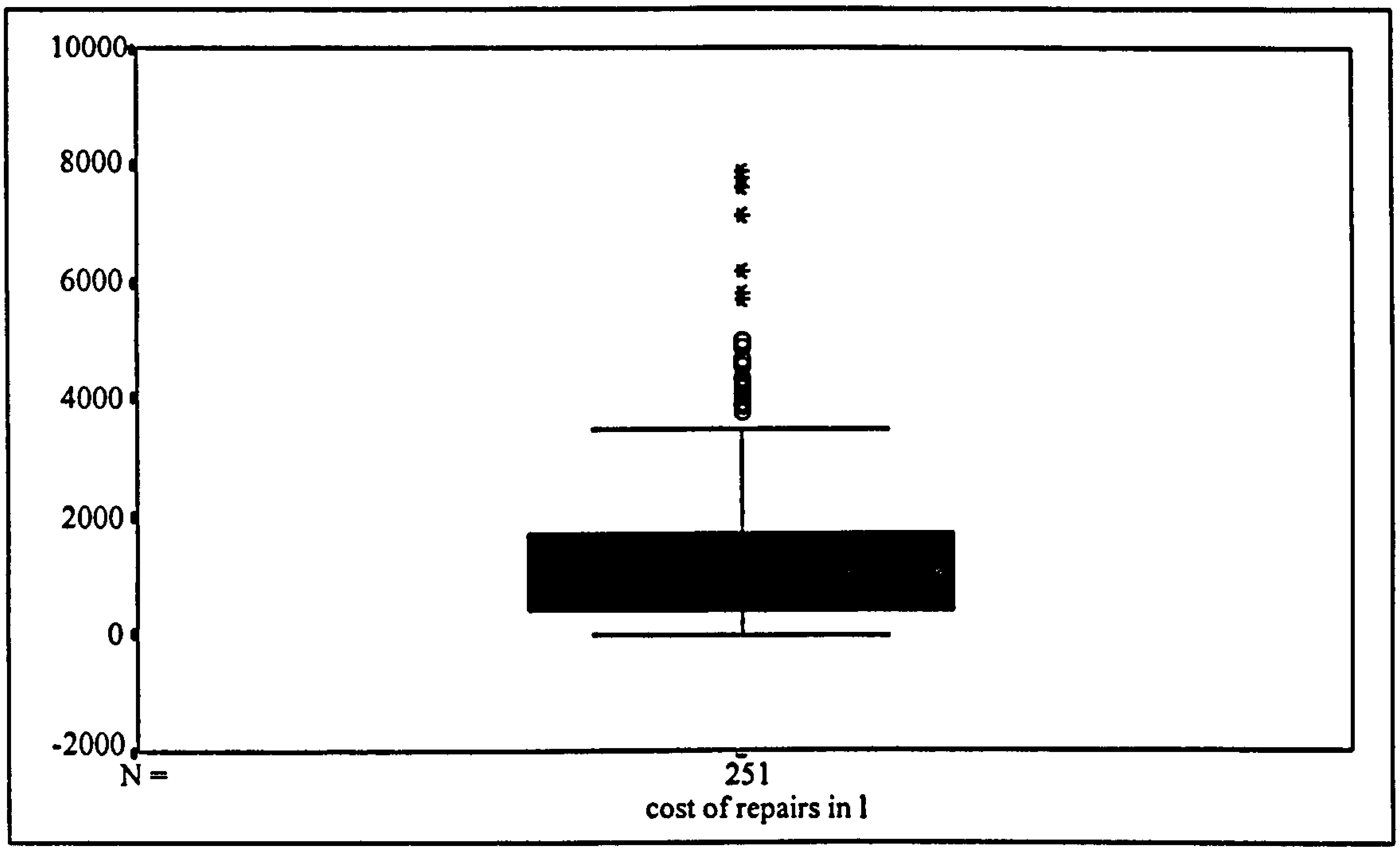


Figure 8.3: Boxplot of uncorrelated maintenance cost

Table 8.2: Expenditure on repairs (MAINCST) in the last five years (before removal of outliers

Valid cases: 251,0 Missing cases: 1,0 Percent missing: ,4

Mean	1413,124	Std Err	95,7994	Min	,0000	Skewness	1,9698
Median	888,0000	Variance	2303557	Max	7857,000	S E Skew	,1537
5% Trim	1227,643	Std Dev	1517,747	Range	7857,000	Kurtosis	4,1611
95% CI for Mean (1224,447; 1601,800)				IQR	1322,000	S E Kurt	,3062

M-Estimators

Huber (1,339)	977,4102	Tukey (4,685)	827,0596
Hampel (1,700; 3,400; 8,500)	945,3492	Andrew (1,340 * pi)	825,3240

```
Frequency    Stem &  Leaf

   31,00        0 *  0000000000000000111111111111111
   32,00        0 t  22222222222222222233333333333333
   32,00        0 f  44444444444444445555555555555555
   25,00        0 s  6666666666667777777777777
   13,00        0 .  8888888999999
   15,00        1 *  000000011111111
   19,00        1 t  2222222233333333333
   10,00        1 f  4444444555
   15,00        1 s  666666666667777
    4,00        1 .  8889
    4,00        2 *  1111
    3,00        2 t  233
    6,00        2 f  444555
    5,00        2 s  66777
    8,00        2 .  88888899
     ,00        3 *
    3,00        3 t  223
    2,00        3 f  44
    9,00 Extremes    (3793), (3895), (3913), (4028), (4129), (4231), (4351)
   11,00 Extremes    (4574), (4601), (4879), (4989), (5706), (5823), (6152)
    4,00 Extremes    (7140), (7604), (7776), (7857)

Stem width:      1000
Each leaf:       1 case(s)
```

Extreme Values
------- ------

5 Highest	Case #	5 Lowest	Case #
7857	Case: 92	0	Case: 152
7776	Case: 187	40	Case: 20
7604	Case: 11	40	Case: 37
7140	Case: 42	50	Case: 79
6152	Case: 29	59	Case: 195

Note: Only a partial list of cases with the value 59 are shown in the table of lower extremes.

Table 8.3: Expenditure on repairs (MAINCST) in the last five years (after removal of outliers

```
Valid cases:        227,0   Missing cases:        ,0   Percent missing:      ,0


Mean       1014,441  Std Err    55,7891  Min         ,0000  Skewness    1,0634
Median     738,0000  Variance  706519,2  Max      3495,000  S E Skew     ,1615
5% Trim    952,0573  Std Dev   840,5470  Range    3495,000  Kurtosis     ,3620
95% CI for Mean (904,5073; 1124,374)     IQR      1079,000  S E Kurt     ,3217

                                 M-Estimators
                                 ------------

Huber  ( 1,339)              839,6965   Tukey  ( 4,685)             759,4013
Hampel ( 1,700; 3,400; 8,500) 859,4752  Andrew ( 1,340 * pi )       753,6132


Frequency    Stem &  Leaf

   31,00        0 *  0000000000000000111111111111111
   32,00        0 t  22222222222222222233333333333333
   32,00        0 f  44444444444444445555555555555555
   25,00        0 s  6666666666667777777777777
   13,00        0 .  8888888999999
   15,00        1 *  000000011111111
   19,00        1 t  2222222233333333333
   10,00        1 f  4444444555
   15,00        1 s  666666666667777
    4,00        1 .  8889
    4,00        2 *  1111
    3,00        2 t  233
    6,00        2 f  444555
    5,00        2 s  66777
    8,00        2 .  88888899
    5,00 Extremes    (3270), (3330), (3426)

Stem width:      1000
Each leaf:       1 case(s)



                               Extreme Values
                               ------- ------

   5    Highest     Case #                5    Lowest      Case #

         . 3495       Case: 209                      0       Case: 152
           3426       Case: 12                      40       Case: 20
           3330       Case: 189                     40       Case: 37
           3270       Case: 221                     50       Case: 79
           3270       Case: 223                     59       Case: 168

Note: Only a partial list of cases with the value       59
      are shown in the table of lower extremes.

Hi-Res Chart  # 2:Boxplot of maintcst
```

These unusually high maintenance costs could be regarded as "shock" to the variable (Akintoye, 1991). This represents situations whereby programmed maintenance work failed to be picked up along with other properties at the appropriate time, and therefore had to be funded from revenue rather than capital accounts.

8.4.4 Measurement, Assessment and Characteristics of Existing Property Condition - (PROPCOND)

While there have been prodigious attempts at estimating future maintenance need and costs of various types of building portfolio (Tucker, 1990; Bromilow, 1987; and Pitt, 1987), little is known about ascertaining the true condition of building stock apart from the traditional quinquennial English House Condition Survey (EHCS) exercise. The EHCS utilises the bespoke condition survey methods (O'Dell, 1991). Where appropriate, the body of information thus collected could form useful primary data for research work. However, the depth of this study requires that more pertinent research data are employed, and indeed, does not support that the same techniques for data collection are utilised. As a result, it was decided inappropriate for reasons of time, cost and inefficiency to seek to establish property condition by merely carrying out a condition survey of properties within the population sample. This led on to the development of the three indices as described in the preceding sections

To assess this dimension of maintenance requirements among the dwelling population sample, data was gathered on three indices. The first of these was the year of last 'prior to painting' repairs and external painting (PTP) on property. Considering the year, points are allocated. Since the maintenance cost data were collected in 1995, the year 1994 was used as the cut-off point. This meant that PTP dated 1994 was awarded a full score of 10, with the score reduced by 1 for each preceding year of PTP. The score, as indicated in Table 8.4 varied from 10 to 0.

In our sample data, the latest PTP was dated 1984. The rationale for the scaling is based upon the premise that a property with more recent (PTP) repairs and external painting is in a generally better condition than one which is more dated (all other things being equal), and therefore scored more highly.

The limitation of this index is the fact that degradation in external joinery (which prior to painting and external painting work seeks to control) is assumed to be strictly time related. Whereas, elevations which are more exposed are not accounted for. To do so will be to introduce minutiae tedium into the factor which will detract from the substance of the investigation.

Table 8.4: Prior to Painting (PTP) scoring

Year of last PTP	Scale
1994	10
1993	9
1992	8
1991	7
1990	6
1989	5
1988	4
1987	3
1986	2
1985	1
1984	0

The second measure of property condition was a subjective assessment of the physical appearance of the building facade (PHYCOND). The object was to make a general but superficial assessment of conditions of brickwall, roof and other external features of the building. Every dwelling was evaluated on a three-point scale indicating the strength of the assessment made. The scale, as indicated in Table 8.5 varied from 5 to 1.

The limitations of this index include in the subjectivity of the assessment and the inapplicability of this criterion to dwellings housed in high rise blocks which do not lend themselves to reasonable assessment of facade upon which reliable inferences could be drawn. To ameliorate this limitation, it was decided to employ an assessment of the lift and communal area conditions as an alternative to brickwall, roof and other external features in high rise blocks.

Table 8.5: Physical condition scoring

Strength of Evaluation	Scale
Good	5
Fair	3
Poor	1

The implication of this was that two dwellings within the sample population housed within the same block will necessarily have the same score. This is also the case for dwellings within the same block of walk-up-flats or cottage-flats. There are however not many of such within the sample in this instance.

Table 8.6: Output Listing for crosstabulation of property type (CLASS1) v. PHYCOND

```
CLASS1                 Page 1 of 1
             Count   |
             Col Pct |
                     |                            Row
                     |    1.00|     2.00|    3.00| Total
PHYCOND     ---------+--------+---------+--------+
             1.00    |    27  |    36   |   28   |    91
                     | 54.0%  | 33.3%   | 32.2%  |  37.1%
                     +--------+---------+--------+
             3.00    |     8  |    47   |   31   |    86
                     |  6.0%  | 43.5%   | 35.6%  |  35.1%
                     +--------+---------+--------+
             5.00    |    15  |    25   |   28   |    68
                     | 40.0%  | 23.1%   | 32.2%  |  27.8%
                     +--------+---------+--------+
             Column       50      108       87      245
             Total     20.4%    44.1%    35.5%   100.0%

      Chi-Square                 Value          DF           Significance
--------------------          -----------      ----          ------------

Pearson                        13.73870          4              .00818
Likelihood Ratio               14.50155          4              .00585
Mantel-Haenszel test for        2.83446          1              .09226
      linear association

Minimum Expected Frequency -   13.878
Number of Missing Observations:  7
```

The output listing displayed in Table 8.6 is a contingency table to test the association, if any, between PHYCOND and CLASS1. The Pearson χ^2 is strongly significant as shown by a p-value (much less than 0.05 at 0.0082). Since the null hypothesis for this statistic is that an association does not exist between the two variables, a significant χ^2 then enables us to reject the H_0 in favour of the H_1. In other words, there is a statistical association between PHYCOND and CLASS1. This conclusion then requires that the contingency table be closely studied to discover any underlying pattern of association between the three classes of properties. The table reveals that 54% of high rise dwellings are classified as poor whilst only about a third of both low rise flats and houses are classified as poor. This accords, if not in magnitude, but at least in direction with social expectation. On this account, the reliability of the scoring of the dwellings on the variable is confirmed. Hence, the shortcomings of the index do not have significant bearing upon its validity.

It is note worthy that the highest score on this index is 5 whilst the lowest is 1. It was decided not to maintain parity of score with the two other indices because of the comparatively high subjectivity of the index.

A third measure of property condition, Propensity to carry out Repair (REPLIKE3) was constructed from tenant's responses to Question No. 8 of the questionnaire in which tenants were asked "how likely they were to carry out repairs identified in earlier Question No. 6" by themselves. Since the index, labelled **REPLIKE3** is intended to measure the willingness of tenants to repair, it is developed by the transformation of the highest level of Likert scale shown by the respondent.

The transformation is given as follows:

$$REPLIKE3 = 3N - 2$$

Where N is the numerical score assigned to a Likert response on the questionnaire instrument.

The object of the transformation is to achieve highest and lowest possible scores of 10 and 1 respectively. The limiting factor on this index is the fact that aged or disabled tenants may not be able to repair, but may nevertheless possess attitude which enables them to keep property in good condition.

Table 8.7 is the result of a T-test between the index (REPLIKE3) and the presence of someone with disability living in the dwelling (DISABLE). Since the F-value is not significant, thus suggesting lack of homogeneity of variance, the Unequal row is appropriate for the interpretation of the results. Given a significance level which approaches unity ($p = 0.994$), the hypothesis of equality of means between the two group of disabled and non-disabled holds. Upon this evidence, it is concluded that tenant's disability does not in any way distort the index.

Table 8.7: T-tests for independent samples of DISABLE

Variable	Number of Cases	Mean	SD	SE of Mean
REPLIKE3 Tenant's disposition to initiate repair				
yes	66	2.7727	1.896	.233
no	183	2.7705	2.017	.149

Mean Difference = .0022

Levene's Test for Equality of Variances: F= .417 P= .519

t-test for Equality of Means Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	.01	247	.994	.285	(-.559, .564)
Unequal	.01	121.66	.994	.277	(-.546, .551)

Furthermore, Table 8.8 is a correlation matrix of REPLIKE3 and TENAGE. In tune with our 'a priori' expectation, a negative and significant correlation exists between Tenant's age and Propensity to Repair. Upon this strong statistical evidence, what is expected to pose a limiting problem to the measure is substantially refuted, and hence its reliability is confirmed.

Table 8.8: Correlation between REPLIKE3 and tenant's age (TENAGE)

	REPLIKE3	TENANGE
REPLIKE3	1.000	-.2204 (P = 0.000)
TENAGE	-.2204 (P = 0.000)	1.000

Limitation of the measure

One would surmise that if the three criteria namely; date of last PTP action, physical (facade) condition and tenant's propensity to Repair severally contribute to a common phenomenon as property condition being measured, then they should each be independent one of another. In other words, any correlation between them should be one of chance rather than of any systematic relationship. In this regard, the existence of any association between REPLIKE3 (Tenant's propensity to repair) and any of the other two can easily be discountenanced without proof. However, at face value, it is not plausible to attribute a relationship of sort between PTP and PHYCOND to chance. Indeed, the possibility exists that a more recent PTP action may have meant that more repairs to the external elements, (which the index PHYCOND measures), have had to be carried out as an adjunct to PTP action. If this proved to be the case, the consequence is that the two criteria significantly measure the same attribute (covariance is high), and hence an unwarranted statistical duplicity of measures. This position is not supported by the Covariance matrix of the regression of PHYCOND on PTP, with a low, though significant β coefficient of 0.0664.

Similarly, the coefficient between PHYCOND and REPLIKE3 (tenant's propensity to repair) is both sufficiently insignificant and low ($\beta = 0.0733, p = 0.252$) to support the hypothesis of non-existence of co-relation. In practice, a systematic relationship is unthinkable. How many tenants would take it upon themselves to provide an external facelift to properties. This is practically unexpected. The results confirm this position. Hence, there exists no valid basis for speculation as to the existence of a systematic relationship between the three measures of existing property condition (PROPCOND). Upon this moderately strong statistical evidence, it can be concluded that the construct PROPCOND is a valid and reliable construct of maintenance requirements or need.

The distribution of the PROPCOND measure

The frequency distribution of the derived scores for Property Condition Index showed that it is a good approximation to a normal distribution (mean =11.171, range =1-21, SD =3.854, skewness =0.013, kurtosis =-.125).

Upon subjecting the data set to an exploratory boxplot analysis, the data is shown to be only very lowly skewed (skewness = 0.013). The kurtosis of the distribution is sufficiently low for the assumption of normality to hold.

This is also confirmed by the boxplot and stem-and-leaf. Given this satisfactory level of normality, this criterion can be employed in subsequent analyses without the violation of the fundamental rule for such analyses.

Of the three measures of PROCOND shown in Table 8.9, only PHYCOND (physical condition) and PTP (date of last prior to paint repairs and external painting) were significantly correlated $(Spearman's\, rho = o.17, P < 0.01)$. The other two correlations were: PTP and REPLIKE3: -0.02, P = 0.72; REPLIKE3 and PHYCOND: 0.07, P = 0.25. These results suggest that multi-collinearity between the three measures is anything but wide spread, and therefore the confounding influence on the results is limited.

Table 8.9: Relationship between three indices of existing condition (PROCOND)

	PTP	PHYCOND	REPLIKE3
PTP	1.000	.1664 (P = .009)	-.0232 (P = .718)
PHYCOND	.1664 (P = .009)	1.000	.0733 (P = .253)
REPLIKE3	-.0232 (P = .718)	.0733 (P = .253)	1.000

Summary of the independent variables

Having established the reliability and the goodness of the data on the indices of maintenance need namely; historic maintenance costs (MAINCST), tenant's satisfaction index for repairs (SATISFY1) and property condition (PROCOND), it was decided to proceed unto further analyses to test relationships with the variables representing characteristics of the respondents (tenants), the dwellings and the environment. This forms the focus of the next segment of this chapter.

8.4.5 Data characteristics for independent variable - Vandalism Index (VANDAL)

The respondents were asked on a four-point scale, to what extent they thought they had problems with different aspects of dwelling and neighbourhood nuisance, namely; noise, car theft and break-ins, litter, graffiti, empty properties and vandalism.

The responses to all these six criteria were combined into one factor. This is achieved by summing up the responses on all the six items for each subject, which resulted into a pseudo-interval scale factor (Kearns *et al*, 1991). The distribution of the resultant factor obtained is shown in Figure 8.4 as a histogram superimposed with a normal curve.

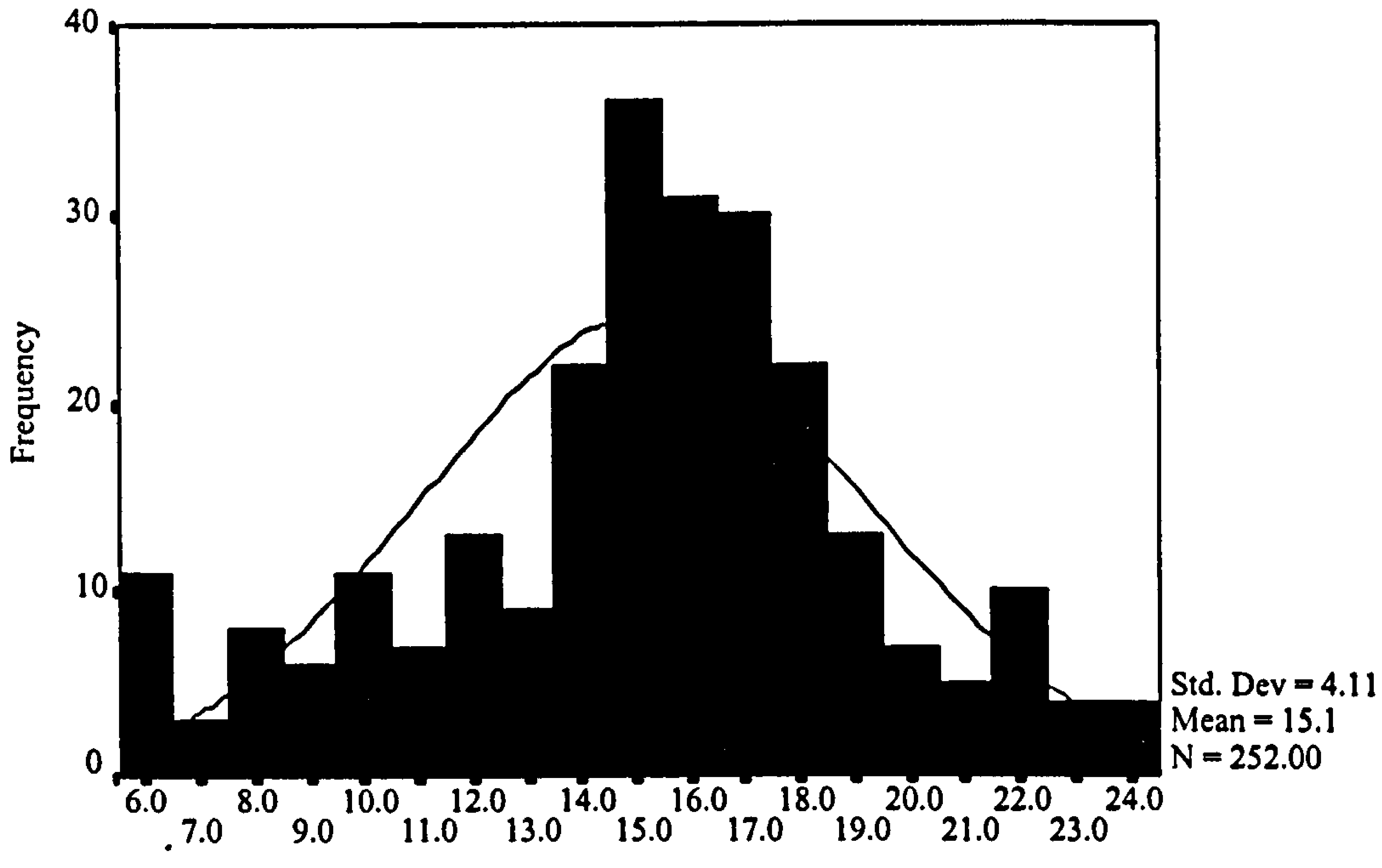


Figure 8.4: Histogram of neighbourhood social rating (VANDAL)

<u>The distribution of vandalism index</u>

The frequency distribution of the derived scores for the vandalism index showed that it is a normal distribution (mean = 15.1, range = 6-24, SD = 4.1, skewness = .2966, kurtosis = -.0582). Statistical summaries for the index are shown in Figure 8.4. The display shows the exploratory data displays of boxplots and stem-and-leaf for derived vandalism index.

The boxplot shows that there is neither an outlier nor extreme value in the derived data, thus confirming the suitability of the data for statistical purpose. As the location of the median within the box is non-eccentric, it expected that the skewness of the distribution is minimal. This position is further corroborated by an extremely low absolute value of the kurtosis (kurtosis = .0582).

Validatory check on the index

In statistical terms, the overall assessment of vandalism (an index of social location) is significantly well-correlated with all of the six component items of social location (see Appendix 3.1). These six items are car problem, noises problem, litter problem, graffiti problem, empty properties and vandalism. Upon this evidence we have chosen to use an aggregate measure composed of the scores on all of the components. All of the six items had correlations stronger than 0.4 (at greater than 99% significance level). Given this strong evidence, it is statistically improbable that the relationships between the items are spurious.

In all, the six component items are significantly correlated with one another without exception. This lends strong credence to the correctness of the choice of the social location stress indicator.

Combining all of the responses into one factor produced a Cronbach's alpha reliability coefficient of 0.86. This suggests that the measure can act as a reasonably reliable scale to measure neighbourhood social rating index (see Appendix 3.3).

Locational consistency of the factor

Considering conventional wisdom, one would surmise that vandalism index should be distinguishable along location. Indeed, the M22 category chosen for the survey is believed to be safer for insurance purposes than the M8 category.

This position is unsupported by the analysis of the responses. As shown in Appendix 3.2, the chi-square is not significant (at 95% level of significance) between the two locations on any of the six component items. It is intriguing to note that none of the six criteria possesses a significant chi-square on location. However, a probability of 0.06241 obtained for empty properties (EMPTPROB) is far from being unequivocal. Even though this is still not significant, it is useful to know in which 'direction the lever tilts'. This low probability purports that problem with empty properties, is more rampant in M22/23 (South) than M8/9 (North).

The consistency of the index is further confirmed by a t-test analysis as follows: Car theft problem in area (t-value = 1.59; P = 0.113); Noise problem in area (t-value = .90; P = 0.368); Litter problem in area (t-value = -.94; P = 0.347); Graffiti problem in area (t-value = -.21; P = 0.835); Empty property problem in area (t-value = 1.7; P = 0.092); and vandalism problem in area (t-value = .73; P = 0.465). See Appendix 3.4 for details. Going by the rule of probability, any observable difference between the two areas of the city must be due to chance occurrence. In reality, it is not uncommon to have pockets of areas which do not exhibit the same characteristics as the broader stereotypification of the larger area. Considering this finding, it is concluded that the decision to assess this criterion (social location vandalism rating) on individual dwelling basis is anything but misplaced.

8.5 Variables selection

It is practically impossible, and in fact not very useful to include in each segment of the investigation all measured variables (Sanders and Thomas, 1992). Rather, the set of variables to be analysed in each case is selected from the total set of variables whilst ensuring that the testing of the hypothesis is objective and thorough. This approach is supported by Nkado (1991), Gilchrist (1984) and Beeston (1983). It has been indicated by these exponents that the identification of potentially relevant variables is all a matter of imagination and common sense.

8.5.1 The independent variables

The dependent variables can be classified into two categories for the purpose of this study namely; interval and non-interval variables (all discussed in chapter two). These variables belong to one or more of the following categories: tenant variables, variables allowing the investigation of how the characteristics of the building object impacts on maintenance requirements, environmental variables and variables describing housing management.

8.5.1.1 Tenant Attributes

There are a number of variables that measure the characteristics of occupier of a residential property including the number of children in dwelling (CHILDCT), attitude to repair problems (REPIRATT), Right-To-Buy speculation (RTBCOMP), gender (GENDER), restraints on physical mobility (DISABLE), move plan, i.e. residential stability (MOVEPLAN), length lived in last home (LENTLAST) and length live in current home (LENTLIVE), employment status (TEMPLOY1) and age (TENAGE). Together, they give an insight into the behaviour and influence of the tenants as they impact upon the dwelling and hence on maintenance need.

The following variables were included in the analysis and were subsequently entered on step number.

1.. CHILDCT Number of children in dwelling
2.. VANDAL New variable derived from vandalism index
3.. RESREPIR council's response to repair
4.. REPIRATT attitude to repair problems
5.. PROPAGE age of property
6.. LOCATION
7.. RTBCOMP Right-to-buy speculation (RTB)
8.. HSGOFFS assessment of service from housing office
9.. GENDER
10.. DISABLE presence of disability or limiting illness
11.. RELET1
12.. MOVEPLAN likelihood of moving from present home
13.. RESVANDL council's response to vandalism
14.. LENTLAST length lived in last home
15.. LENTLIVE Length lived in current home
16.. FLAREA floor area
17.. TENAGE tenant's age
18.. CLASS1 Class of dwelling (dwelling type)
19.. BED number of bedrooms
20.. SIZE size of property

8.5.1.2 Property Attributes

This family of variables has been dealt extensively with in chapters six and seven. As a follow-up to these with other variables, we have nevertheless, because of the different methodological framework employed for this segment of the analyses, included some measurable property variables in the analysis. The conclusions arrived at confirm the inference drawn from those analyses. The variables which are tested include the age of dwelling, floor area, dwelling type and number of bedrooms, none of which eventually proved to be significant.

8.5.1.3 Environmental Attributes

An environment inhabited by man is subject to wear, decay, attrition and destruction (Ward, 1973). A major environmental influence which exacerbates degradation process is labelled vandalism.

Architectural social theory contends that social behaviour of tenants is influenced by the form of housing design, hence, vandalism as a social behaviour is inherent in the design (Newman, 1972). This theory has been described by Ward (1973) as one of social escapism seeking to shift the responsibility from the social deviant to the social enhancer. A housing estate is a community of dwellings which share common environmental characteristics prominent of which is geography. The characteristic of an estate environment is an amalgam of complex inter-relationships. There exists the danger of over-simplification in an attempt by social theorists to find meaning to what is typically a complex web of social and technological network. In reality, an environment is constantly undergoing symbiotic processes. The individuals who live in an environment constantly influence it, whilst the environment influences the individuals. In the final analysis, it is this complex symbiosis that eventually determines what an estate is and will be in terms of its overall characteristics.

A useful index for assessing the quality of a human environment is possibly the extent of damage to properties (built and otherwise) in the environment, which quite often does reflect on the general tidiness of the area. Thus portraying the result of the quality of human interaction with that environment. To this end, Crosby (1985) attempted to develop an environmental status index which essentially comprised of an evaluation of social changes in the area and the physical environment.

In his study of user - responses to housing environments, Crosby (1985) demonstrated that residential property conditions vary according to the environmental status of the area in which property is located. The major environmental variables identified by him are social changes in the area as well as the physical environment. It is therefore possible that these two characteristics, in the main, will influence the maintenance requirements of a property. The variables that could be tested under this grouping are Vandalism index and location.

8.5.1.4 Property Management Attribute

This group of variables is a measure of the attitude of the housing management team to reported property defects or identification of these defects. Whilst it is possible to argue that these attributes are not truly variable, they actually fall short of being 'a given' as every housing management team operates under some sorts of constraints be it political, operational or financial. This group of variables includes Council's response to repair (RESREPIR), quality of service from housing officers (HSGOFFS) and councils response to vandalism (RESVANDL).

8.5.2 Characteristics of the Non-Interval variables

Table 8.13 shows the frequency distributions of the listed variables on the non-interval scale.

Inference from the qualitative data

The dwellings within the sample population are classified into flats in high rise; constituting 21% of the sample size, flats in low rise 43%, and houses constituting 36%.

Table 8.10 shows that 74% of the tenants within the sample are unlikely to seek a move from dwelling in the future, whilst 26% hope to move sooner or later. Almost all (98%) the dwellings have central heating. In almost 77% of the dwellings, no child was present. This appears to account for the high per cent of those who are unlikely to move in comparison with those who are likely, which in turn may be accounted for by the high average age of main tenants. This is coroborated by the fact that 74% of the respondents are above the age of 45years.

In 73% of the cases, only one adult lives in dwelling with or without children. 48% of the respondents are men whilst 52% are women. Sixty-eight per cent of the sample do not express any Right-to-buy speculation on their property. Only a few, about 13% of dwellings have had relet work carried out on them. This indicates that tenants are generally very stable.

Appendix 3.5 shows that the chi-square statistics on dwelling types for variables MOVEPLAN, RESNUISE, RESREPIR, RESVANDL, HSGOFFS, REPIRATT, GENDER, TENAGE and DISABLE are greater that 0.05; and therefore insignificant. This is not surprising, as it is undesirable to have these variables exhibit characteristics patterned along the line of dwelling type. Thus confirming the lack of bias within the sample data. However, the relationship between dwelling type and the four other variables, namely; LOCATION, RELET, RTBCOMP and CHILDCT are significant. This implies that there is some dependence between dwelling type and each of the four variables. Except for location, the results are expected. A significant relationship with relet indicates that some dwelling types are more prone to being void than others. As indicated in the crosstab of Appendix 3.5, 53% of all relets relate to cottage flats, with 34% to high rise flats and 13% to houses. An underlying cause for this is partly in the design and subsequent dampness problems which are more prevalent with cottage flats (Housing NEWS, undated).

Table 8.10: Frequency tables for the dependent variables

MOVEPLAN likelihood of moving from present home

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
very unlikely	1	100	39.7	44.8	44.8
unlikely	2	65	25.8	29.1	74.0
likely	3	28	11.1	12.6	86.5
very likely	4	30	11.9	13.5	100.0
don't know	9	29	11.5	Missing	
	Total	252	100.0	100.0	

RESREPIR council's response to repair

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
very bad	1	23	9.1	9.1	9.1
bad	2	41	16.3	16.3	25.4
well	3	114	45.2	45.2	70.6
very well	4	55	21.8	21.8	92.5
don't know	9	17	6.7	6.7	99.2
	14	1	.4	.4	99.6
	33	1	.4	.4	100.0
	Total	252	100.0	100.0	

RESVANDL council's response to vandalism

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
very bad	1	32	12.7	12.8	12.8
bad	2	36	14.3	14.4	27.2
well	3	33	13.1	13.2	40.4
very well	4	8	3.2	3.2	43.6
don't know	9	141	56.0	56.4	100.0
	.	2	.8	Missing	
	Total	252	100.0	100.0	

RESNUISE council's response to nuisance

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
very bad	1	42	16.7	16.8	16.8
bad	2	31	12.3	12.4	29.2
well	3	36	14.3	14.4	43.6
very well	4	11	4.4	4.4	48.0
don't know	9	130	51.6	52.0	100.0
	.	2	.8	Missing	
	Total	252	100.0	100.0	

HSGOFFS assessment of service from housing office

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
very poor	1	25	9.9	9.9	9.9
poor	2	46	18.3	18.3	28.2
good	3	100	39.7	39.7	67.9
very good	4	45	17.9	17.9	85.7
don't know	9	36	14.3	14.3	100.0
	Total	252	100.0	100.0	

RTBXISE exercising right to buy right

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
never would consider	1	160	63.5	67.8	67.8
may consider it one	2	32	12.7	13.6	81.4
considered it but do	3	29	11.5	12.3	93.6
still considering it	4	15	6.0	6.4	100.0
	9	16	6.3	Missing	
	Total	252	100.0	100.0	

REPIRATT attitude to repair problems

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
I only repairs - thr	1	45	17.9	18.1	18.1
I would rather fix m	2	57	22.6	22.9	41.0
I take time in repor	3	64	25.4	25.7	66.7
I report repairs imm	4	83	32.9	33.3	100.0
	9	3	1.2	Missing	
	Total	252	100.0	100.0	

GENDER

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
male	1	123	48.8	48.8	48.8
female	2	129	51.2	51.2	100.0
	Total	252	100.0	100.0	

CIRCUM occupant's circumstance

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	1	.4	.4	.4
single adult without	1	142	56.3	56.3	56.7
single adult with ch	2	41	16.3	16.3	73.0
2 or more adults wit	3	52	20.6	20.6	93.7
2 or more adults wit	4	16	6.3	6.3	100.0
	Total	252	100.0	100.0	

DISABLE presence of disability or limiting illness

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
yes	1	66	26.2	26.5	26.5
no	2	183	72.6	73.5	100.0
	.	3	1.2	Missing	
	Total	252	100.0	100.0	

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LOCATION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
M8 / M9	1	146	57.9	57.9	57.9
M22 / M23	3	106	42.1	42.1	100.0
	Total	252	100.0	100.0	

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CHEATG central heating in dwelling

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
yes	1	246	97.6	97.6	97.6
no	2	6	2.4	2.4	100.0
	Total	252	100.0	100.0	

Valid cases 252 Missing cases 0

- -

CLASS1 collapsed class

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1.00	53	21.0	21.0	21.0
	2.00	108	42.9	42.9	63.9
	3.00	91	36.1	36.1	100.0
	Total	252	100.0	100.0	

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RELET1

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
yes	1	32	12.7	12.7	12.7
no	2	220	87.3	87.3	100.0
	Total	252	100.0	100.0	

Valid cases 252 Missing cases 0

- -

RTBCOMP COMPRESSED RTB

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1.0	192	76.2	81.4	81.4
	2.0	44	17.5	18.6	100.0
	.	16	6.3	Missing	
	Total	252	100.0	100.0	

CHILDCT Number of children in dwelling

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No child present in	1	193	76.6	76.6	76.6
one or more child pr	2	59	23.4	23.4	100.0
	Total	252	100.0	100.0	

TENAGE tenant's age

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
16 - 30 years	1	30	11.9	11.9	11.9
31 - 45	2	36	14.3	14.3	26.2
46 - 65	3	62	24.6	24.6	50.8
over 65 years	4	124	49.2	49.2	100.0
	Total	252	100.0	100.0	

A significant χ^2 for CHILDCT confirms the fact that certain dwelling types are less suitable for families with children. Because most rational prospective Right-To-Buy speculators are least likely to consider high rise flats or even cottage flats, with the preference generally being for houses, a significant χ^2 with RTBCOMP is not surprising.

8.5.3 Interval scale

Statistical summaries for data on the interval scale are shown in Table 8.11. Appendix 3.7 shows the exploratory data displays of stem-and-leaf and boxplots for the seven variables. The length of each row in a stem-and-leaf plot corresponds to the number of cases that fall into a particular interval. Each case is represented with a symbol that corresponds to the actual observed value which is divided into the leading digit (the stem) and the trailing digit (the leaf).

Table 8.11: Summary of variables statistics

Number of valid observations (listwise) = 222.00

Variable	Mean	Std Dev	Minimum	Maximum	Valid N	Label
LENTLIVE	17.32	13.75	3	63	251	Length lived in current home
LENTLAST	14.11	13.58	0	60	223	live length in last home
PROPAGE	48.07	19.78	7	105	252	age of property
SIZE	4.56	.98	1.00	7.50	252	size of property
BED	2.15	.73	1	4	252	number of bedrooms
FLAREA	763.98	208.14	319	1411	252	floor area
VANDAL	15.09	4.11	6	24	252	NEW VARIABLE DERIVED

The boxplot further summarises information about the distribution of the values of a variable. It plots the median, removed from the rest. Fifty percent of the cases have values within the box. The limits of the box are the largest and smallest values that are not outliers. Outliers are values larger and smaller than 1.5 box-lengths (interquartile range) from 75th or 25th percentiles respectively. Extremes are cases larger or smaller than three box lengths from the 75th or 25th percentiles respectively.

8.5.3.1 Interpretation of interval data

Three of the variables, VANDAL, FLAREA and PROPAGE are moderately normal, whilst the remaining four show fairly skewed distributions. The sample comprises dwellings ranging in age from 7 to 105 years. The range of total gross floor area is 319 to 1411 m^2, with a mean of 766 m^2 and a median value of 711 m^2.

The number of bedrooms in, and size of dwelling are discrete with very limited range. The range of number of bedrooms is 1 to 4, with mean and median value of 2. Whilst the size ranges from 1 to 7 with mean value of 4.58, and median value of 5.38. This explains the uniqueness of stem-and-leaf for these two variables.

8.5.4 Summary of Variables

In this section, the values of each measured variable has been considered as a separate entity. The sample data comprises dwellings with just one and the same tenancy for time period ranging from 3 to 62 years ($\mu = 16.68$ years). The chi-square display in Appendix 3.5 generally accords with our *a priori* expectation with the exception of just one variable - location. This has to do with sampling distribution rather than any attribute which has to do with the validity or otherwise of the data collected. Given this level of satisfactory interaction within the data set, detailed analysis to investigate the relationships between these variables and other measured variables are carried out in the next section.

8.6 Relationships between the three indices and selected variables

Analysis of the data begins with an investigation of the relationships between the three indices and the independent variables. As the bivariate statistics in Table 8.15 indicate location is significant only on PROPCOND. Properties in M8/9 area of the city are in poorer condition. Surprisingly, this does not appear to affect the satisfaction of tenants in this area nor is there any evidence that this trend is predicated by differential maintenance expenditure pattern on properties in the two areas.

Table 8.12: Relationship between location, house type, social rating of neighbourhood (vandal) and maintenance need indicators

Maintenance requirement measure	*Location*[1]	*House type*[2]	*Social rating of neighbourhood*[3]
Maintenance cost	7600.0 (p=.9088)	9.4234 (p=.0090)	.0431 (P= .497)
PROPCOND	5966.5 (p=.0019)	10.1805 (p=.0059)	-.1555 (P= .013)
SATISFY	7014 (p=.9637)	4.8597 (p=.0880)	-.1634 (P= .011)

[1]Location: 1=M8/9 North of Manchester; 2=M22/23 South of Manchester. Test statistic: Mann-Whitney U

[2]House type:1=High rise flat; 2=Cottage/walk-up flat; 3=House. Test statistic: Kruskal-Wallis

[3]Vandal: Derived variable measured on interval scale. Test statistic: Pearson correlation coefficent

The rejection of the null hypothesis, and that there is no relationship between maintenance cost and location supports our expectation of non-discriminatory repair action along the line of location. This, as would be expected, leads to non-differential in repair satisfaction level among tenants across the city as supported by the lack of significance in the relationship between SATISFY and Location. Whilst the relationships are statistically insignificant, comparisons of the mean scores on maintenance cost and SATISFY on location reveal that tenants in the M22/23 area benefit from slightly higher expenditure on maintenance, and at the same time enjoying commensurably higher level of satisfaction.

A significant relationship between PROPCOND and location suggests that generally, there is a higher backlog of concealed repair works in the M8/9 area than in the M22/23 area. This leads one to suggest that the tenants in the M22/23 area spend more of their own money on their dwellings either because they are generally more affluent, or there is the existence of stronger chain neighbourhood influence in personal expenditure in the up-keep of dwellings.

House type (CLASS) is significantly related to all three of the maintenance requirement measures. The high rise flats appear to have the least maintenance expenditure and, not surprisingly, tenants in this type of dwelling are least satisfied with repair works on property. As expected, this category of dwellings are in the poorest condition. At face value, the supposition should be that if they are in the poorest condition, a non-discriminatory repair system will tend to spend more on this property category. It would only be reasonable to expect this where property condition is not conditioned by the attitude of the tenants or a group of tenants. Hence, it is unrealistic to expect that every act of vandalism within the dwelling would qualify for immediate repair by the housing management team.

Between the low rise flats and houses, the issue is more difficult to interpret. Whilst houses generally score more highly on both maintenance expenditure and PROPCOND, the low rise flats dwellers are generally more satisfied with repair works on properties. This implies that house dwellers are generally more demanding on the repair system. This may have an underlying explanation in the creation of artificial repair needs by house tenants, who because of their circumstance are more disposed to having children in dwelling and are generally of lower age brackets. These categories of tenants, as shown by experience, tend to be 'defect prone' and litigous by being more disposed to using the legal aid facilities in 'twisting the hands' of housing officers to carry out repairs.

There are significant relationships between social rating of dwelling (VANDAL) and two of the maintenance requirement measures (PROPCOND and SATISFY1). The results of Table 8.15 show that these two measures are negatively correlated with VANDAL. In other words, properties in more socially deprived locations are likely to be in poorer conditions, with tenants being generally more difficult to please with the repair systems. The relationship between VANDAL and maintenance cost is not significant. The expectation however, would be that where properties are most vulnerable to social menace, there would be a correspondingly higher response from the housing team to rectify resultant defects in a non-discriminatory environment. Although this may at first seem to be a surprising finding, it should be borne in mind that only those acts of social menace which expose the dwelling to the direct influence of the elements (such as broken panes) that command immediate, if any repair response from the housing management team.

As this part of the analysis has indicated, the M22/23 area in the sample have generally better conditioned dwellings. Across the two areas, it would appear that high rise flats tend to be undermaintained.

8.7 PREDICTING MAINTENANCE NEED

There appears to be a link between maintenance need on the sample dwellings and their location, house type and social index of neighbourhood. It is plausible, however, that multi-collinearity between the three independent variables has contributed to confounding the results. For example, given the concentration of high rise flats in the M8/9 area of the city it is possible that what passes for a 'house type effect' on maintenance need may simply be a surrogate for M8/9 systematic undermaintenance in relation to M22/23 area.

8.7.1 Repair cost record model

The results of repair cost regression are shown in Table 8.13. Full regression model using all 20 independent variables has a multiple coefficient of determination (R^2) of 0.6021 and an F ratio of 5.4465 which is significant at better than 99% level of significance. This value of (R^2) shows that the variables altogether explain 60 per cent of the variations in repair costs.

As a first step in developing a better model, the variables with t-values of less than 1.6 (i.e. 90% significance level) were removed from the equation. The reason for including variables at 90% significance level is that some of those variables may improve their significance to the predicted 95% level when some of the weak variables are eliminated., This resulted in the regression model shown in Table 8.14 which comprises of four variables all of which satisfied the 95% level of significance. The (R^2) dropped from 0.6021 to 0.4963, but the F ratio improved very substantially from 5.4465 to 25.4723, at better than 99% significance level. The improved F ratio indicates that the latter model (Table 8.18) is yet still more highly significant than the former (Table 8.17). Hence, Table 8.18 results are the final model. The four variables in this final model include RELET1, DISABLE, LENTLIVE and TENAGE.

Table 8.13: Initial regression equation on maintenance cost

**** M U L T I P L E   R E G R E S S I O N ****

Listwise Deletion of Missing Data

Equation Number 1   Dependent Variable..   MAINTCST   cost of repairs in last 5

Block Number 1. Method: Enter

LENTLIVE	MOVEPLAN	LENTLAST	RESREPIR	RESVANDL	HSGOFFS	RESREPIR	REPIRATT
GENDER	TENAGE	DISABLE	PROPAGE	SIZE	BED	LOCATION	FLAREA
CLASS1	RELET1	VANDAL	RTBCOMP	CHILDCT			

Variable(s) Entered on Step Number

1..	CHILDCT	Number of children in dwelling
2..	VANDAL	NEW VARIABLE DERIVED FROM VANDALISM INDE
3..	RESREPIR	council's response to repair
4..	REPIRATT	attitude to repair problems
5..	PROPAGE	age of property
6..	LOCATION	
7..	RTBCOMP	COMPRESSED RTB
8..	HSGOFFS	assessment of service from housing office
9..	GENDER	
10..	DISABLE	presence of disability or limiting illne
11..	RELET1	
12..	MOVEPLAN	likelihood of moving from present home
13..	RESVANDL	council's response to vandalism
14..	LENTLAST	length livedin last home
15..	LENTLIVE	Length lived in current home
16..	FLAREA	floor area
17..	TENAGE	tenant's age
18..	CLASS1	collapsed class
19..	BED	number of bedrooms
20..	SIZE	size of property

Multiple R	.77593
R Square	.60206
Adjusted R Square	.52824
Standard Error	1288.19987

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	20	180765797.18766	9038289.85938
Residual	162	268832342.58283	1659458.90483

F = 5.44653   Signif F = .0000

* * * * M U L T I P L E   R E G R E S S I O N * * * *

Equation Number 1   Dependent Variable..   MAINTCST   cost of repairs in last 5

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
LENTLIVE	24.007668	10.403702	.203760	2.308	.0223
MOVEPLAN	-97.234418	104.819027	-.065804	-.928	.3550
LENTLAST	7.722416	8.205887	.068205	.941	.3481
RESREPIR	-25.280748	53.004032	-.031452	-.477	.6340
RESVANDL	50.591023	32.062873	.110955	1.578	.1165
HSGOFFS	-58.678160	45.581401	-.085752	-1.287	.1998
REPIRATT	96.719162	93.388921	.068787	1.036	.3019
GENDER	114.314680	206.907355	.036422	.552	.5814
TENAGE	-495.003745	150.023268	-.346737	-3.300	.0012
DISABLE	-1165.261360	239.522070	-.333317	-4.865	.0000
PROPAGE	8.203113	6.898755	.102649	1.189	.2362
SIZE	241.881324	350.998906	.147188	.689	.4917
BED	-410.431012	462.048862	-.189406	-.888	.3757
LOCATION	-69.295699	111.795086	-.043726	-.620	.5362
FLAREA	-.229373	1.336660	-.029152	-.172	.8640
CLASS1	115.211423	272.800908	.055832	.422	.6733
RELET1	-1894.658681	364.113538	-.393113	-5.203	.0000
VANDAL	33.027868	25.978855	.087654	1.271	.2054
RTBCOMP	242.382759	265.306919	.059452	.914	.3623
CHILDCT	153.924584	335.564557	.040946	.459	.6471
(Constant)	6219.034598	1194.136894		5.208	.0000

End Block Number   1   All requested variables entered.

Table 8.14: Final regression equation on maintenance cost

Variable(s) Entered on Step Number

1.. RELET1
2.. DISABLE presence of disability or limiting illne
3.. LENTLIVE Length lived in current home
4.. TENAGE tenant's age

Multiple R	.70448
R Square	.49629
Adjusted R Square	.28465
Standard Error	1292.41103

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	4	170188333.00822	42547083.25205
Residual	242	404218955.98774	1670326.26441

F = 25.47232 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
LENTLIVE	13.730517	7.098941	.124357	1.934	.0543
TENAGE	-439.795654	98.686161	-.304883	-4.457	.0000
DISABLE	-1233.060329	188.514388	-.357797	-6.541	.0000
RELET1	-1286.729636	285.146408	-.283350	-4.513	.0000
(Constant)	7087.276230	591.423418		11.983	.0000

End Block Number 1 All requested variables entered.

8.7.1.1 Inference from the Maintenance Cost Models

What this group of models seems to elicit is that all the 20 independent variables account for about 60 per cent of the variation in repair costs within the local authority housing organisation. As the original 20 variables were fine-tuned on statistical grounds, we were able to reduce them to just four variables which explain 50 per cent of the total variation in the dependent variable.

The final model (Table 8.18) includes four variables which all fall into the category of tenant attribute variables (RELET1, DISABLE, LENTLIVE and TENAGE). This exclusive inclusion of variables in only one of the four areas of tenant, property, environmental and property management attributes is surprising. It indicates that the tenant characteristics are the dominant factors affecting day-to-day repair expenditure; as a component of overall maintenance need of a residential property.

It is surprising because, on *a priori* grounds, it was expected that all the four areas should inter-play in determining expenditure to a lesser or greater extent. Initial speculation suggested that environmental factors should bear significantly upon MAINTCST (the dependent variable), which in this case has not been supported. This confirms earlier finding, in chapter Six, which puts vandalism as one of least influential on overall maintenance need; second only to age of property. It is worthy of note that the Tolerance of the four variables are reasonably high, which enable us to reject any suggestion of multi-collinearity as a problem within the models. Upon this evidence, we could not explain away the features of the model on the grounds of inter-correlations with other variables in the property, environmental and property management domains.

The partial coefficients indicate that, in magnitude, DISABLE, is the strongest variable influencing repair expenditure, followed by TENAGE, RELET1 and LENTLIVE. The positive coefficient for the variable LENTLIVE is contrary to expectation. The speculation would have been that the longer a tenant stayed in the dwelling, the less would be his/her demands for repairs. However, this difference in impact can be explained in three ways. Firstly, the awareness of tenants increases with length of tenure, and as he becomes more aware of his rights, the higher the cost records associated with his dwelling, especially where the tenant is likely to claim entitlement to legal support. Secondly, the degree to which pressure is generated by the tenant on local housing management team increases with tenant's self confidence which, in turn, increases with length of tenure. Thirdly, whilst newer tenants become satisfied once pre-occupation needs are met by the housing management team, when those needs cease to be 'real needs' in the perception of the tenants, higher order needs are naturally created by the tenants. Many of such needs may only be artificial. Therefore, the longer the tenant is in occupation, the more demanding he is likely to be and hence may generate more artificial defects which may, some of the time, have to be attended to by the housing management group.

The negative coefficient for the variable RELET1 at (0.2834) indicates that repair expenditure decreases where a property has had relet work carried out within the period in question. This observation seems to contradict theoretical expectations since tenancy turnover means more work being carried out on dwelling in order to secure replacement tenants and hence increased maintenance expenditure. However, the contradiction disappears where and if relet works constitute an encapsulation of all existing as well as impending defects into one 'big' repair action. Thus resulting in an 'economies of scale' which proves to be more cost efficient, as well as possessing some attribute of pro-active and preventative maintenance. Hence, what is observed is that repair cost is reduced in the medium or long term where there is tenancy turnover in so far as such a turnover is not so frequent as to make the event itself short termed. The problem with this trend however, lies in the time-value of such lump sum expenditure as well as the management of day-to-day repair as a 'revenue account' cost item.

The variable for DISABLE, which represents the physical well-being of tenants, has a positive influence. What shows to be a negative partial coefficient is in actual sense a positive coefficient since the scoring of the variable in the original data is in reverse order with; 1 - representing an existence of disabled person and a higher score representing an absence of person with disability. It is also note worthy that some items of maintenance in dwellings occupied by disabled persons are carried out under social services account rather than housing revenue account. Thus strengthening the negative correlation, but the impact is not strong enough as to off-set additional expenditure by housing department on disabled person's dwellings.

It is interesting that this variable has the strongest influence on repair expenditure. It is useful to mention that repair expenditure profile does not include for ad-hoc social services works carried out on properties for disabled persons, for, in the presence of this, it becomes obvious why there would be a strongly positive inter-relationship. On the contrary, it would appear that the strong influence is supported on account of the sensitivity with which disabled persons are treated by housing officers, and therefore any requests made by such persons. Therefore, a tenant's report for defects which may pass for trifle in the case of non-disabled tenant, tends to receive more sympathetic and urgent action when such a report comes from a disabled tenant. Secondly, one would expect that disabled tenants are likely to spend more hours at home, and therefore, likely to generate more work, especially condensation related problems. Furthermore, because they tend to spend more time at home, they are in better position to identify at much earlier stage, defects which other tenants will ignore or may not notice. Thirdly, where the disabled person is a parent, the chances of do-it-yourself (DIY) works being done on a dwelling become very remote, and hence, such defects fall to housing management for rectification.

The negative partial coefficient for the variable TENAGE is interesting. What it suggests is that the older the tenant is, the lower the repair costs. Anecdotal evidence as well as findings by Alner and Fellows (1990) in their study of school buildings suggests that age of property should be the strongly influencing factor in repair expenditure. In this research, these findings are unsupported but appear to have been reversed. The results suggest that PROPAGE is not a significant influencing factor, and that the age of tenant (TENAGE) is more important in influencing residential property repair expenditures. However, following from the preceding chapter, the ageing influence exerts itself more significantly on some building components (damaged goods and wall ties) rather than the whole, and possibly synergises with some other influence to exert significant bearing on the building.

The direction of this influence can be explained in three ways. Firstly, older tenants are least likely to have children leaving with them, and where they do, they are not likely to be very young children, who may tend to generate more repairs by way of accidental damage to vulnerable building components. Also, because dwellings with older tenants are likely to be of lesser occupation density, condensation related problems associated with higher density may not be more than off set by longer hours at home for this category of tenants (older tenants). Secondly, even though MOVEPLAN is not here found to be a significant variable, it is plausible that because younger household tend to be more mobile, they are less likely than older ones to commit personal expenditure on dwelling, which is then passed on to housing management. Thirdly, with a major proportion of their time devoted to work and tending younger children, younger households would have less time at their disposal to carry out DIY duties on the property in comparison with older households. Hence work which may well have been carried out by the tenant for personal gratification (rather than for statutory requirements) would end up being passed on to housing management team.

8.7.1.2 Excluded variables from Maintenance Expenditure Models

The regression model began with 20 independent variables, 16 of which failed the 95% level of significance criterion and thus were excluded from the final regression equation in (Table 8.18). Their exclusion may be due to the variables' limited influence on repair cost or that while they do affect repair expenditure, they do so less directly than other variables for this particular purpose.

The variable (RESVANDL) was excluded from the final model even though the response of the housing team to complaints generally is believed to have some influence on repair expenditure. As seen in the regression model, this variable is the strongest of all the 16 excluded variables in terms of t-value, which is significant at just below 90% significance level. The exclusion may be due to possible effect of inter-area transfer of housing staff. In which case, two or more respondents (tenants) in different areas may actually be assessing one and the same housing staff. The housing officer concerned may be the last direct contact with these respondents over the period in question regarding the same subject matter. It is also possibly that tenants' personality relating to their ages such as TENAGE have a more direct influence. The two variables are significantly, though lowly, correlated (correlation coefficient = 0.1411).

The variable (HSGOFFS) was also excluded. It is possible that the exclusion of this variable rests upon the same premise as with RESVANDL. Even though no significant correlation exists between HSGOFFS and any of the four significantly influential variables included in the final model, the strength of the correlation between (RESVANDL) and (HSGOFFS) [Rho = 0.22] at 99% significance level enables us to draw similar conclusion.

The fact that the partial coefficients of HSGOFFS and VANDAL are very close to each other in magnitude, though in opposite directions at -0.0858 and 0.0877, respectively indicates that the degree of responsiveness of housing officers and vandalism index of area / dwelling have an equal but opposite impact on repair expenditure profile.

Of the top most four influential variables excluded from the final model, the behaviour of the variable PROPAGE appears to be most interesting. The age of property, though not sufficiently significant to be included in the final model, the partial coefficient suggests that its influence on repair cost is substantially greater than both HSGOFFS and VANDAL, but failed the 95% criterion. The variable's failure of the t-test may be that its contribution has been substantially represented by the two successful variables with which it was proved to be significantly correlated, namely; RELET (Rho = 0.1329) and LENTLIVE (Rho = 0.1963).

8.7.2 Property condition model

The results of property condition regression are shown in Table 8.15. Full regression model using all 20 independent variables has a multiple coefficient of determination (R^2) of 0.2493 and an F ratio of 2.7065 which is significant at better than 99% level of significance.

In an attempt to develop a better model, variables at less than 90% significance level were excluded from the first model. This resulted in the regression model shown in Table 8.16, leaving a model with just three of the original variables, namely; VANDAL, BED and SIZE, two of which satisfied the required 95% level of significance. Although the final model satisfied the statistical criteria, and also showed consistent improvement on the previous F values, due to the low explanatory power (R^2) = 0.0609 which is an excessively large drop from the original R^2 at 0.2493, the model was therefore rejected on the ground of spuriousness, and possible endogenous interference among the variables, thus distorting the various observed t-values which are used in deciding the inclusion or exclusion of variables.

Table 8.15: Initial regression equation on property condition

```
****   M U L T I P L E   R E G R E S S I O N   ****
Listwise Deletion of Missing Data

Equation Number 1    Dependent Variable..    PROPCOND    Assessment of overall con
Block Number  1.  Method:  Enter
   LENTLIVE MOVEPLAN LENTLAST RESREPIR RESVANDL HSGOFFS  RESREPIR REPIRATT
   GENDER   TENAGE   DISABLE  PROPAGE  SIZE     BED      LOCATION FLAREA
   CLASS1   RELET1   VANDAL   RTBCOMP  CHILDCT

Variable(s) Entered on Step Number
   1..     CHILDCT   Number of children in dwelling
   2..     VANDAL    NEW VARIABLE DERIVED FROM VANDALISM INDE
   3..     RESREPIR  council's response to repair
   4..     REPIRATT  attitude to repair problems
   5..     PROPAGE   age of property
   6..     LOCATION
   7..     RTBCOMP   COMPRESSED RTB
   8..     HSGOFFS   assessment of service from housing offic
   9..     GENDER
  10..     DISABLE   presence of disability or limiting illne
  11..     RELET1
  12..     MOVEPLAN  likelihood of moving from present home
  13..     RESVANDL  council's response to vandalism
  14..     LENTLAST  live length in last home
  15..     LENTLIVE  Length lived in current home
  16..     FLAREA    floor area
  17..     TENAGE    tenant's age
  18..     CLASS1    collapsed class
  19..     SIZE      size of property
  20..     BED       number of bedrooms
```

Multiple R	.49929
R Square	.24929
Adjusted R Square	.15718
Standard Error	3.51649

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	20	669.34463	33.46723
Residual	163	2015.61189	12.36572

F = 2.70645 Signif F = .0003

* * * * M U L T I P L E R E G R E S S I O N * * * *

Equation Number 1 Dependent Variable.. PROPCOND Assessment of overall con

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
LENTLIVE	-.019051	.028149	-.066169	-.677	.4995
MOVEPLAN	.063096	.285660	.017473	.221	.8255
LENTLAST	-.031695	.022355	-.114671	-1.418	.1582
RESREPIR	.037671	.144578	.019180	.261	.7948
RESVANDL	-.121541	.087402	-.109296	-1.391	.1662
HSGOFFS	.175903	.124355	.105200	1.415	.1591
REPIRATT	-.284094	.254741	-.082778	-1.115	.2664
GENDER	-.625486	.562058	-.081750	-1.113	.2674
TENAGE	-.514691	.409396	-.147533	-1.257	.2105
DISABLE	.735759	.653473	.086212	1.126	.2619
PROPAGE	-.001697	.018828	-.008692	-.090	.9283
SIZE	-1.547019	.953564	-.386264	-1.622	.1067
BED	2.309004	1.259277	.437596	1.834	.0685
LOCATION	.149649	.304175	.038782	.492	.6234
FLAREA	-.001880	.003604	-.098696	-.522	.6026
CLASS1	1.138203	.744518	.226502	1.529	.1283
RELET1	.240772	.992993	.020450	.242	.8087
VANDAL	.144428	.070829	.157116	2.039	.0431
RTBCOMP	-.345163	.723054	-.034665	-.477	.6337
CHILDCT	.509287	.905002	.055481	.563	.5744
(Constant)	11.993572	3.259312		3.680	.0003

End Block Number 1 All requested variables entered.

Table 8.16: Intermediate regression equation on property condition

```
**** M U L T I P L E   R E G R E S S I O N ****


Listwise Deletion of Missing Data

Equation Number 1    Dependent Variable..   PROPCOND   Assessment of overall con

Block Number  1.  Method:  Enter      SIZE      BED       VANDAL


Variable(s) Entered on Step Number
   1..     VANDAL     NEW VARIABLE DERIVED FROM VANDALISM INDE
   2..     BED        number of bedrooms
   3..     SIZE       size of property


Multiple R           .26057
R Square             .06790
Adjusted R Square    .05662
Standard Error      3.74304

Analysis of Variance
                     DF       Sum of Squares      Mean Square
Regression            3            253.09835         84.36612
Residual            248           3474.56435         14.01034

F =      6.02170       Signif F =  .0006


------------------ Variables in the Equation ------------------

Variable               B          SE B         Beta          T  Sig T

SIZE           -1.009347       .742021     -.255500     -1.360  .1750
BED             2.299861       .996439      .433225      2.308  .0218
VANDAL           .141333       .057622      .150706      2.453  .0149
(Constant)      8.693144      1.725316                   5.039  .0000


End Block Number   1   All requested variables entered.
```

8.7.2.1 Correcting for Endogenous Interference in the Property Condition Model

The first step towards correcting for possible confounding influence on the model is to compartmentalise the variables. The object being that if all the 20 variables explain about 25% of the variation in property condition, any improved model from this, whilst substantially improving on the F value and its significance, should not, nevertheless, only so very marginally explain the variations in the dependent variable.

The most rational approach towards categorisation for this purpose appears to be along the line shown under section 8.5.1 namely; tenant, property, environmental and property management attributes.

The variables pertaining to each of these areas were isolated and subjected to regression analysis whilst retaining the initial dependent variable. The regression runs show that variables appertaining to three of the four identifiable areas, namely; property, environmental and property management attributes are very weak models. However, the regression run for the variables under 'tenant' attributes proved almost equally as strong as the original regression model consisting of all the 20 variables which nevertheless failed the set 95% criterion.

The first model consists of 11 independent variables which proved to explain about 80% of the total variation accounted for by all the 20 variables put together. In the modified property model, the full regression model is shown in Table 8.17a. The R^2 of 0.1963 and the F ratio of 3.7745 are both significant at greater than 99% significance level. To further improve the model, the variables which did not meet the 90% criterion for the t-values were excluded from the model. This resulted in Table 8.17c model consisting of three variables all which now met the 95% criterion for the t-value. The R^2 dropped from 0.1936 to 0.1288, but the F ratio improved to 10.7962, which is almost triple the previous value.

These results lead us to a similar inference as in the repair cost models, i.e. they indicate that tenant characteristics are the dominant factors affecting property condition to the exclusion of environmental and property attributes.

The negative coefficient for the variable TENAGE is in the same direction as its influence on repair costs. In the first place, it was not expected that tenant's age should be a significant influential variable on property condition. This surprising observation could however be explained on account of 'cause and effect' phenomenon between tenant's age (TENAGE) and vandalism (measured in the main by the variable VANDAL). An examination of the full property condition model reveals that these two variables have opposite signs for the partial coefficients. This confirms that vandalism occurs more frequently where tenants are younger. The validity of this inference is confirmed by the fact that the variable VANDAL proved to be one of three factors along with TENAGE that showed significant t-value in the final model, and in opposite directions

The underlying cause for this trend lies in the fact that the presence of older children within the dwelling in general and the neighbourhood in particular could act as a catalyst for the general deterioration of property condition. As expected, such children are more common with younger, rather than older families.

The negative coefficient for the variable LENTLAST indicates that tenants who lived longer in previous dwellings are currently living in more 'run down' properties within the local authority. As revealed by the correlation matrix, LENTLAST is significantly positively correlated with TENAGE (Rho = 0.40). This confirms conventional wisdom which would seem to suggest that older tenants would more probably have lived elsewhere and for longer period as well. The direction of the beta sign for LENTLAST and TENAGE is negative whilst VANDAL is positive. Having said that, there is no ground to suggest that the three variables are essentially measuring the same attribute, as indeed they cannot, given their correlation matrix: LENTLAST and TENAGE at 0.3987*; LENTLAST and VANDAL at 0.0176; TENAGE and VANDAL at -0.0048 with just one of the three relationships being significant (as indicated with *).

The underlying explanation for this observation about the variable (PROPCOND) may be based purely on dogma for housing preference among older tenants who tend to show preference for older dwelling types. Older people seem to believe that older houses are less prone to defects whereas younger people tend to show preference for newer ones (which usually appear more attractive). Since substantially newer buildings present a more attractive facade than older ones, then the direction of the relationship is no surprise.

8.7.2.2 Inference from the Property Condition Model

Given the very low R^2 for the property condition model, there are the chances that the model is discarded as unreliable notwithstanding the significant F-ratio. In chapters Six and Seven, the internal attributes of the dwelling building are explored as attributes such as design, construction and standard are practically immeasurable and cannot therefore be examined in this chapter. Age of dwelling was found to exert very low influence on maintenance requirements. The exclusion of this variable from the final model confirms the previous inference drawn in chapter Six. The fifth attribute, i.e. vandalism is in this chapter measured with the aid of proxy variables as discussed earlier, and is incorporated in the final model.

When compared with design, construction and standard, vandalism possesses a comparatively low contribution to maintenance requirement. These three attributes are the most influential factors on physical condition of a building, but because no proxy variables have been devised to measure them, it has not been possible to incorporate them into the model. This accounts for the very low but signifcant R^2.

Table 8.17: Final regression equations on property condition

Table 8.17a: Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
LENTLIVE	.010529	.023712	.036693	.444	.6576
MOVEPLAN	-.031975	.277102	-.008857	-.115	.9083
LENTLAST	-.040312	.021241	-.147185	-1.898	.0594
REPIRATT	-.366057	.250183	-.107411	-1.463	.1452
GENDER	-.885653	.553509	-.116214	-1.600	.1114
TENAGE	-.753751	.442257	-.216742	-1.704	.0901
DISABLE	.469599	.610434	.055110	.769	.4428
VANDAL	.169196	.064898	.184095	2.607	.0099
RTBCOMP	-.131569	.687908	-.013383	-.191	.8485
CHILDCT	1.243394	.803626	.135627	1.547	.1236
TEMPLOY1	.237556	.484157	.050013	.491	.6243
(Constant)	11.184218	2.674504		4.182	.0000

Multiple R	.43994
R Square	.19355
Adjusted R Square	.14227
Standard Error	3.53602

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	11	519.13725	47.19430
Residual	173	2163.10058	12.50347

F = 3.77450 Signif F = .0001

Table 8.17b: Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
LENTLAST	-.046685	.020034	-.161919	-2.330	.0207
TENAGE	-.885218	.255503	-.243134	-3.465	.0006
VANDAL	.128410	.060298	.133895	2.130	.0343
GENDER	-.792228	.505534	-.101201	-1.567	.1185
(Constant)	13.812065	1.477600		9.348	.0000

Multiple R	.37221
R Square	.13854
Adjusted R Square	.12274
Standard Error	3.66805

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	4	471.71609	117.92902
Residual	218	2933.10005	13.45459

F = 8.76497 Signif F = .0000

Table 8.17c: Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
LENTLAST	-.051803	.019832	-.179668	-2.612	.0096
TENAGE	-.799432	.250398	-.219572	-3.193	.0016
VANDAL	.129221	.060496	.134741	2.136	.0338
(Constant)	12.397120	1.173528		10.564	.0000

Multiple R	.35894
R Square	.12884
Adjusted R Square	.11691
Standard Error	3.68022

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	438.67382	146.22461
Residual	219	2966.14232	13.54403

F = 10.79624 Signif F = .0000

8.7.3 Satisfaction model

In the satisfaction group, maintenance need is defined in terms of the perception of individual tenants about their property. The full regression model is given in Table 8.18 The (R^2) of 0.5141 and the F ratio of 3.4567 are both above the 95% significance level.

To develop a better model the procedures from the previous round were repeated and all variables with a t-value less than 1.6 were excluded from the model. This resulted in Table 8.19 model in which all the independent variables improved their t-values to the 95% significance level. The adjusted (R^2) dropped from 0.4232 to 0.3610, but the F ratio increased from 3.4567 to 8.1024. With all variables statistically significant, this model represents the final model.

The model for this index seems to be a lot more representative than for the previous two models as it includes tenant variables (MOVEPLAN and LENTLAST), environmental variable (VANDAL) and property management variables (HSGOFFS and RESREPIR).

The direction of the influence of each of these variables as elicited in the Beta column of the regression equations in Table 8.19 is justified on a priori ground. A cursory examination of the full regression equation reveals that gender of tenants and the age of properties are not significantly influential on the dependent variable with partial coefficients of 0.0019 and 0.0077 respectively. The analysis shows that the non-disabled tenants tend to be generally less satisfied with maintenance work, with negative though low Beta value. This is not surprising as dwellings with disabled occupiers have the benefit of having works carried out on them both from housing revenue account and ad hoc social services account.

The influence of variable VANDAL in the final equation is as expected and very highly significant too. It indicates that dwellings where vandalism is rampant breed unsatisfied tenants. In this case, the cause of dissatisfaction is not merely with the act

Table 8.18: Initial regression equation on tenant's satisfaction

```
                 * * * *   M U L T I P L E   R E G R E S S I O N   * * * *

Listwise Deletion of Missing Data

Equation Number 1    Dependent Variable..   SATISFY1

Block Number  1.  Method:  Enter
   LENTLIVE MOVEPLAN LENTLAST RESREPIR RESVANDL HSGOFFS  RESREPIR REPIRATT
   GENDER   TENAGE   DISABLE  PROPAGE  SIZE     BED      LOCATION FLAREA
   CLASS1   RELET1   VANDAL   RTBCOMP  CHILDCT

Variable(s) Entered on Step Number
   1..    CHILDCT   Number of children in dwelling
   2..    RESREPIR  council's response to repair
   3..    VANDAL    NEW VARIABLE DERIVED FROM VANDALISM INDE
   4..    REPIRATT  attitude to repair problems
   5..    PROPAGE   age of property
   6..    HSGOFFS   assessment of service from housing offic
   7..    LOCATION
   8..    GENDER
   9..    RTBCOMP   COMPRESSED RTB
  10..    DISABLE   presence of disability or limiting illne
  11..    RELET1
  12..    MOVEPLAN  likelihood of moving from present home
  13..    LENTLAST  live length in last home
  14..    RESVANDL  council's response to vandalism
  15..    LENTLIVE  Length lived in current home
  16..    FLAREA    floor area
  17..    TENAGE    tenant's age
  18..    SIZE      size of property
  19..    CLASS1    collapsed class
  20..    BED       number of bedrooms


Multiple R           .71697
R Square             .51405
Adjusted R Square    .42320
Standard Error     79.17288

Analysis of Variance
                    DF      Sum of Squares      Mean Square
Regression          20        433349.15756      21667.45788
Residual           151        946520.06400       6268.34479

F =       3.45665       Signif F =  .0000
```

* * * * M U L T I P L E   R E G R E S S I O N * * * *

Equation Number 1   Dependent Variable..   SATISFY1

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
LENTLIVE	.270603	.645067	.040382	.419	.6754
MOVEPLAN	-12.123608	6.730705	-.142617	-1.801	.0737
LENTLAST	1.199754	.526371	.184849	2.279	.0241
RESREPIR	14.668442	3.791723	.277834	3.869	.0002
RESVANDL	-.877377	2.097418	-.033597	-.418	.6763
HSGOFFS	4.948273	3.012568	.119959	1.643	.1026
REPIRATT	-4.680640	6.143145	-.057432	-.762	.4473
GENDER	-.335821	13.258849	-.001870	-.025	.9798
TENAGE	11.938181	9.514045	.146981	1.255	.2115
DISABLE	-8.351086	15.081537	-.042083	-.554	.5806
PROPAGE	.035902	.444373	.007713	.081	.9357
SIZE	-13.605495	21.817215	-.144138	-.624	.5338
BED	7.908106	29.056915	.062600	.272	.7859
LOCATION	8.046796	7.135741	.089102	1.128	.2612
FLAREA	-.021816	.083804	-.048203	-.260	.7950
CLASS1	14.082570	17.874942	.117931	.788	.4320
RELET1	4.765112	23.377527	.017054	.204	.8388
VANDAL	-3.084456	1.658267	-.144915	-1.860	.0648
RTBCOMP	-23.074811	16.924600	-.100252	-1.363	.1748
CHILDCT	-1.469432	20.762060	-.006990	-.071	.9437
(Constant)	272.071498	74.414863		3.656	.0004

End Block Number   1   All requested variables entered.

Table 8.19: Final regression equation on tenant's satisfaction

* * * * M U L T I P L E   R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1   Dependent Variable..   SATISFY1

Block Number 1. Method: Enter
VANDAL MOVEPLAN LENTLAST HSGOFFS RESREPIR

Variable(s) Entered on Step Number

1..	RESREPIR	council's response to repair
2..	VANDAL	NEW VARIABLE DERIVED FROM VANDALISM INDE
3..	LENTLAST	live length in last home
4..	HSGOFFS	assessment of service from housing offic
5..	MOVEPLAN	likelihood of moving from present home

Multiple R	.61945
R Square	.38372
Adjusted R Square	.36104
Standard Error	83.20211

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	5	280447.51940	56089.50388
Residual	180	1246066.29697	6922.59054

F = 8.10239   Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
VANDAL	-2.931022	1.515229	-.132046	-1.934	.0546
MOVEPLAN	-16.294330	5.974899	-.187881	-2.727	.0070
LENTLAST	1.180340	.443310	.180533	2.663	.0085
HSGOFFS	6.420747	2.788007	.156609	2.303	.0224
RESREPIR	6.676894	2.236721	.201500	2.985	.0032
(Constant)	270.979439	29.523226		9.179	.0000

End Block Number 1 All requested variables entered.

of vandalism as with the attitude of the housing management to repair works in such vandalism prone dwellings and housing areas. This inference is borne out by the significant contributions of HSGOFFS and RESREPIR to the model. The positive directions of the latter two variables confirm that responsive housing management impacts on maintenance requirements to tenant's satisfaction. With the result that care on the part of management is reinforced with concomitant care from satisfied tenants. Most puzzling of all is the influence of length of tenure in previous accommodation. Longer tenure in previous accommodation leads to reduced maintenance need. This is accounted for by the fact that such tenants are more likely to have acquired 'do-it-yourself' skills which allow them to carry out minor repairs at little cost to themselves. Also, the correlation between TENAGE and LENTLAST is a positive one, and the impact of the former on the latter may be at play in this instance, i.e. LENTLAST may be a surrogate for TENAGE.

8.8 Conclusion

In this chapter three models dealing with maintenance needs have been developed. The three models are statistically satisfactory. Combining the three models leads us to suggest that nine out of the 20 independent variables are significant factors in the determination of maintenance requirements for housing stock. These include TENAGE, DISABLE, RELET1, VANDAL, LENTLAST, LENTLIVE, MOVEPLAN, HSGOFFS, and RESREPIR. The direction of the influence of each of these variables is clearly elicited in the Beta columns of the regression tables.

The apparent low explanatory power of the models is in line with our expectation. The factors affecting maintenance requirements have elsewhere been established to be multifaceted (see chapters Five, Six and Seven), and the attributes herein discussed are some of the prominent variables which lend themselves to measurement of some sort. Hence, it is never anticipated that these families of variables should explain a disproportionately high percentage of the variation in maintenance requirements.

This chapter has brought to focus the strong influence of tenants' attributes upon maintenance need. It also shows that it is insufficient for maintenance managers to base their understanding of the subject purely on physical characteristics and attributes of the building object. The manager must also build into any budgetary prediction an allowance for variations in tenant profiles and their effects upon maintenance generation.

CHAPTER 9
SUMMARY AND CONCLUSIONS

9.1 Summary

As stated in chapter One, the overall objective of the research was to develop a framework for isolating a group of factors influencing maintenance requirements in public sector housing. It is expected that a factorial framework will enhance:

1. the awareness and knowledge of issues bearing upon maintenance which will be of value to housing managers;
2. the development of maintenance strategies in housing which will help identify optimum efficiencies and economics through the judicious allocation of resources;
3. the awareness of designers of new housing schemes of the factors influencing maintenance generation and the performance of dwellings; and
4. the field of knowledge currently available because of the inadequacies of available literature.

It can be seen from chapter Two that it is possible, from the literature search, to establish a three-fold categorisation of the factors, i.e.:

- Internal attributes of the building object;
- External attributes; and
- The mediatory role of the stockholder

This enabled a number of hypotheses to be formulated and tested. These hypotheses revolve around the notion that maintenance requirements are influenced by:

(i) a number of precise building object attributes;

(ii) the surrounding environment in which dwellings are located;

(iii) the characteristics of the tenants; and

(iv) housing management responsiveness.

The obvious starting point in establishing a suitable methodology was an in-depth survey of available information the Manchester Council housing records. An examination of maintenance cost records over a five-year period for a sample of 66 dwellings showed an absence of patterned relationships. An analysis of variance of maintenance expenditure between semi-detached houses and cottage flats revealed that there is no significant difference between them. A scatter plot of the data revealed that the size of dwellings both in terms of number of bedrooms and floor area does not have significant bearing upon maintenance expenditure.

Following from this, some inadequacies were identified in the cost records and therefore could not be relied upon totally as a principal yardstick for measuring maintenance requirements. This is partly due to costs being distorted because some tenants influenced the demand, priority and ordering of building maintenance through their desire to use legal powers by way of the legal aid system, and partly due to their forcefulness and determination to get work done.

However, it was felt that if the cost data was supported and enhanced by other data then it was possible to provide a sound basis on which to establish the independent variables. Two complementary areas were identified; one being targeted at the tenants themselves, and the other at the existing condition of the buildings.

Complementary information from tenants was aimed at determining how satisfied they were with works carried out on their properties. Studies into tenants' satisfaction are commonly agreed in their findings that dwellings with the least satisfied tenants tend to be in poorer state of repairs than those with more satisfied tenants (Burbridge and Smith 1973; Shankland 1971; Stevenson *et al* 1967). Developing a measure for this attribute clearly corrected some of the deficiencies found in the cost records.

From the literature search on the development of public housing in the UK, a common datum can be established for the tenants involved in the study. Exponents are generally agreed on the fact that council housing tenants fall into the lowest 25 per cent income brackets of the national population. This makes the sample a truly homogeneous sample, therefore enhancing the reliability of the index developed from the participants. A strategy for the measurement of satisfaction expressed by tenants in relation to the quality of repairs was devised from the tenant questionnaire. The resulting index proved to be a highly reliable index with a reliability index of 0.8583.

The information on the existing condition of the building object was assembled on three measures namely;

- The year of last prior to painting repairs and external painting;
- An assessment of the physical appearance of the building facade; and
- The propensity of tenants to carry out their own repair.

Our rejection of the popular condition survey approach to determining property condition is advanced on account of time, expense, unpredictable subjectivity and impracticality.

Having established a framework of independent variables for use in the statistical process, it is apt to elucidate upon what constitute maintenance for the purpose of the this study, bearing in mind the present lack of consensus among authors on the various grades of work to existing buildings. One of the major requirements in dealing with maintenance is to specify what the terms mean. A conceptual meaning of maintenance that formed the basis for the study is figuratively illustrated in the Figure 9.1. It illustrates that what is considered to be maintenance action could be a combination of the different areas or categories of work namely; rehabilitation, improvement and modernisation coupled with what is customarily referred to as repair action. This combination can be quite loosely arranged and somewhat limited in extent.

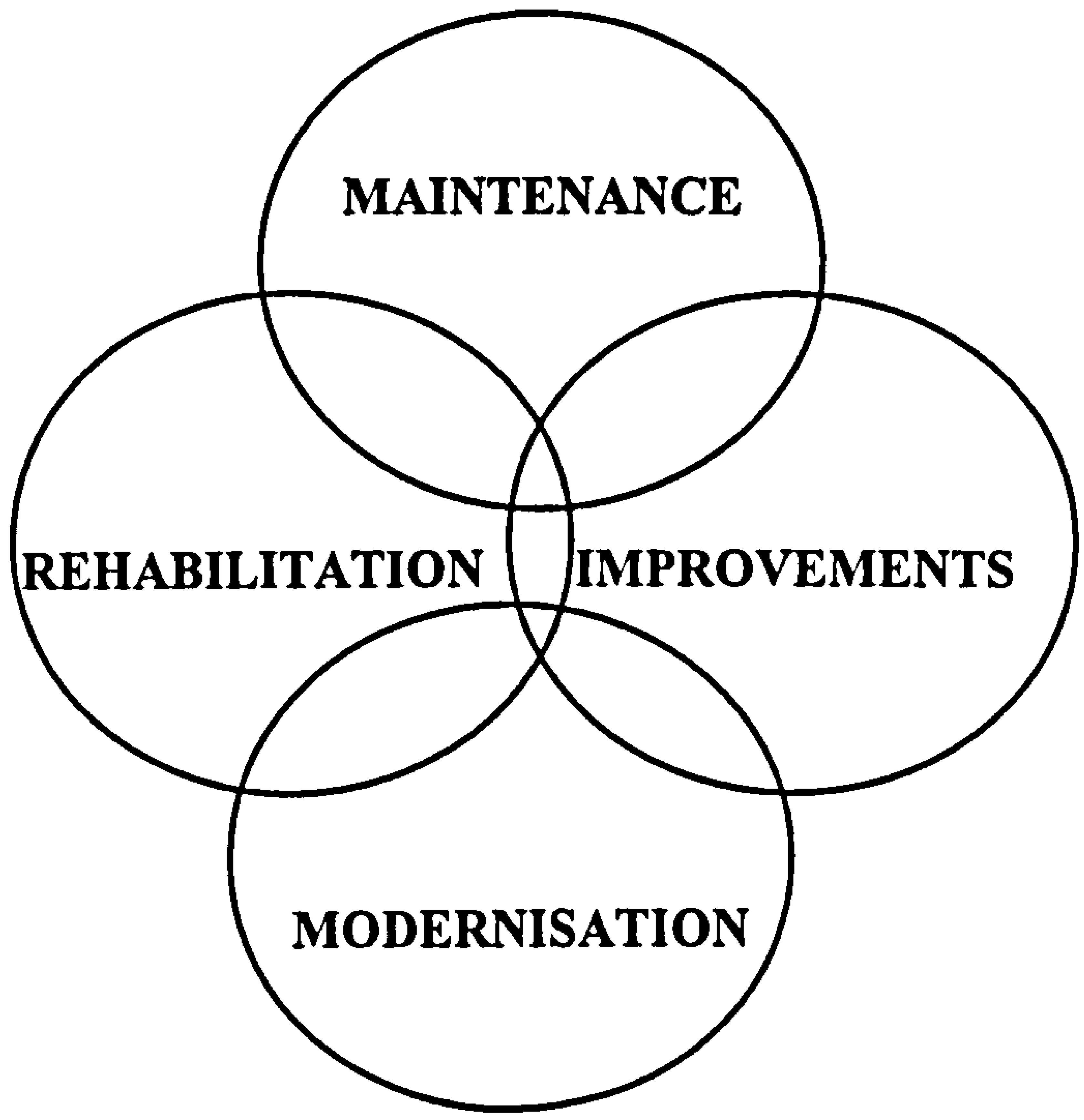

Figure 9.1: Work classification on existing building portfolio

A literature search on factors determining or influencing maintenance needs revealed that authors generally had fairly limited appreciation of the subject. Academic efforts presently concentrate on building object characteristics such as; age, design, vandalism, construction type and changing standards as the prime determinants of maintenance requirements. Works incorporating social factors into this list are few and far between. The influence of funding and budgets issues on maintenance are also well documented. However, the influence which tenants exert on maintenance requirements has seldom been given consideration and has certainly not been recognised as being of equal importance with the more obvious determinants of maintenance. Any serious studies of tenants are only to be found in the realm of social studies rather than construction management. With the consequence that property construction experts are seeking to find answers to a complex multi-faceted problem by studying a convenient subset of the problem rather than the whole. This imbalance has been redressed in this study.

The influence of the mediatory role of local housing management in regulating and responding to maintenance need and requirements has hardly been acknowledged. It is the housing officer who decides whether or not report made by a tenant is genuine and deserving of repair action. When that decision is made, it also rests with the housing officer to determine response time for such defect.

Control of local budgets also influences maintenance requirements because it influences the response time of housing officers and building surveyors to defect reports made by tenants. Each area housing team leader is allocated annual repairs budget and is responsible for controlling expenditure within those cash limits. In order to exercise control, the team leader requires an accurate estimate of their committed expenditure on a job by job and summary basis. What is conspicuously lacking at the moment is a pre-planned estimate of likely repair cost for a given year before the commencement of the financial year. This results in budget shortfalls and the most crucial repair needs have to be foregone in most area offices. In some instances surplus budgets tend to be inefficiently spent-up towards the end of the financial year in few area offices.

Chapter Six presented the results and interpretations of data analyses following the steps described in chapter two - with respect to building surveyor's questionnaire. The response rate to the survey was 45%. A Kendall concordance test of the survey data showed that defects causing criteria can be prioritised along component line as shown in the table below.

What Table 9.1 demonstrates is that if we wanted, for example, to determine the soundness of a dwelling in terms of its design (which encompasses specifications and detailing), we should concentrate any monitoring of performance processes on those attributes identified, i.e. expansion cracks, dampness in floors, condensation, slab failure and rot. Whilst reliable in terms of design, the measures do not tell us to what extent such defects impact upon the overall or total maintenance requirements.

Table 9.1: Indicative component defects on defect-cause criteria

Defect-Cause Criteria	Indicative component
Age	Patch repair to roof; Wall ties failure; Bay, canopy and chimney flashing; Electrical faults; Balcony concrete repair
Vandalism	Removing graffiti; Damaged security door; Reglazing; Internal door repair or replacement; Fencing repair or replacement
Design	Expansion crack; Damp floor; Condensation problem; Slab and screed failure; Dry or wet rot
Construction	Dry or wet rot; Slab and screed failure; Damp floor; Water ingress; Defective damp proofing
Changing Standard	Condensation problem; Electrical faults; Heating repair or replacement of part; Gas leakage; Defective roof structure

To do this it was necessary to determine the relationships which exist between the defect-cause criteria namely; age, construction, design, changing standard and vandalism from the data set. For statistical purpose, the data needed to be tested for reliability. To achieve this, the analysis of the residuals showed that the data set is statistically good with approximate normal shape and lack of pattern in the plots of residual values against the predictor variables. Linear regression applied to the data on individual predictor variables proved useful in that it showed that three of the five defect-cause criteria were significant at 10% level of significance. The three significant defect-cause criteria are construction, design and changing standard. Given these initial results, it was considered worthwhile to undergo a combined regression analysis in order to gain an insight into the characteristics of the data sets as a whole.

A combined regression model of the five variables proved to be significant at 95% level with (F-ratio = 4.05815; P = 0.0497; and R^2= .31869). A significant F-statistic as shown confirms that linear relationships exist between the dependent and independent variables included in the regression equation. Notwithstanding, the regression model displayed strong characteristics of multicollinearity as shown by insignificant tolerance values on four of the five variables. These four criteria are age, changing standard, design, and construction.

The regression model showed that the features of the building object explain about 32% of the variation in maintenance need. The order of importance of the five criteria was as follows: 38.7% for standards, 22.7% for construction, 21.5% for design, 11.6% for vandalism and 5.8% for age. This means that of the five defect-cause criteria identified, changing standard is the most influential on maintenance requirements, construction second, design third, vandalism fourth and age fifth. This result is most fascinating especially with respect to age. What it shows is that the age of a dwelling property is not very influential on maintenance requirements in comparison with the other four factors. The obvious existence of multicollinearity shown by high tolerance values required that further analysis be conducted with the aid of factor analysis technique given in chapter seven.

In the light of these relationships between the five criteria, Table 9.1 could be developed further to convey the level of importance of the indicative component defect. This would help building surveyors to identify the cause of defects and thereby enhance the determination of the correct remedies for such defects. Table 9.2 shows the level of impact the various building defects have. The darker the row in which a defect is located, the greater the impact such a defect has on overall maintenance (the darker the row, the greater the impact). In essence, the greater the impact of a defect, the greater the probability of more serious problems occurring.

As illustrated, it is of much lesser consequence to ignore a wall tie failure than it is to ignore a rot problem. The table does not however give any indication of the seriousness of the chain reaction that could be triggered by the neglect of a defect from one category to the other. It is noteworthy that defects are repeated across defect-cause. For example, an electrical defect could be explained as being attributable to either age or changing standard. The decision on where a particular electrical defect belongs will be best made in the light of other associated events linked with such defects. Such overlap, is the result of what the study found to be the existence of inter-correlations between defect-cause criteria which is indicated by high tolerance probabilities.

Table 9.2: Contributions of internal attribute criteria to overall maintenance requirements

Defect-Cause Criteria	Indicative component	Contribution of components under each criterion to overall maintenance
Age	Patch repair to roof; Wall ties failure; Bay, canopy and chimney flashing; Electrical faults; Balcony concrete repair	about 2%
Vandalism	Removing graffiti; Damaged security door; Reglazing; Internal door repair or replacement; Fencing repair or replacement	about 4%
Design	Expansion crack; Damp floor; Condensation problem; Slab and screed failure; Dry or wet rot	about 7%
Construction	Dry or wet rot; Slab and screed failure; Damp floor; Water ingress; Defective damp proofing	about 7.5%
Changing Standard	Condensation problem; Electrical faults; Heating repair or replacement of part; Gas leakage; Defective roof structure	12.5%
TOTAL CONTRIBUTION OF GROUP OF DEFECT CAUSES TO OVERALL MAINTENANCE		**32%**

Chapter Seven sets out to investigate how, and to what extent, each of the identified causative criteria is related and to identify which groups of building components are associated on factorial level. The technique of factor analysis was employed. The validity of the technique was confirmed by a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy in excess of 0.50 at (0.66177). With the aid of Varimax Orthogonal Rotation method, it was possible to delineate distinct clusters through minimising the number of factors on which components have high loadings. Nine factors were extracted from the mass of data. The factors were identified and each given an appropriate name as follows in decreasing order of importance:

Factor 1	Dwelling external influence;
Factor 2	Design integrity standard of dwelling;
Factor 3	Tenant's lack of care index;
Factor 4	Influence of changing and evolving standard;
Factor 5	Ageing influence;
Factor 6	Vandalism - Design pull effect;
Factor 7	Design - construction inadequacy;
Factor 8	Accidental damage restricted to building envelope; and
Factor 9	Dwelling orientation and soil condition.

This chapter showed clearly that the building object is not influenced as a whole by identifiable defect causes but as individual components. This is akin to the principle of cost planning in quantity surveying which splits up the building into its elements in contrast to controlling the overall cost of the building as one lump sum.

Chapter Eight started with the presentation of a methodological framework for the measurement of maintenance need. Three indices were identified namely DLO repair cost, tenants' satisfaction and existing condition of property. Repair costs relate to cost information obtained from computer records on dwelling basis. Tenants' Satisfaction index was obtained with the use of questionnaire from which an interval scale index was derived (after Kearns *et al*, 1991).

Existing Condition of Property index was based upon an appropriate combination of three measures namely; the year of last prior to painting repairs and external paintings, physical appearance of the building facade and tenant's propensity to carry out repair work. This last measure has been incorporated because the tenant's disposition to care for his or her home impacts upon the attractiveness of the building to some extent. These three measures were combined to produce property condition index.

Rigorous validatory tests namely boxplot, stem-and-leaf plot, and normality test analyses were conducted on the three indices which allowed manipulations to be made to the data as necessary to ensure reliability, efficiency and validity as measures of dwelling maintenance requirement. Using the tenant's questionnaire survey instrument, this process was followed by rigorous regression model testing to identify significant independent variables from a list of characteristics pertaining to tenant, property, environmental and housing management attributes (20 in all). Of these groups of variables, those relating to tenant's attribute proved to be most influential among the significant factors.

In all, nine variables were significant at 95% level. This means that the variable concerned have substantial impact (which cannot be merely attributed to chance) upon one or more of the three indices of maintenance requirements. These variables are; Tenant's age, Presence of disability or limiting illness, Relet work carried out on property in the last five years, Vandalism index of dwelling, Length lived in current home, Length lived in last home, Likelihood of moving from present home, Tenant's assessment of service from housing office, and Council's response to repair need.

The models showed with their beta values the strength and direction of the relationship of each variable to the index on which it proved to be significantly influential. Further discussions of the implications of these values follow.

Table 9.3: Variables with substantial non-chance impact on the three indices

Significant variables on each of the index models showing strength and direction		
Maintenance cost	**Property Condition**	**Satisfaction**
Length lived in current home (+.1244)	Length lived in last home (-.1700)	Length lived in last home (+.1805)
Tenant's age (-.3049)	Tenant's age (-.2196)	Likelihood of moving from present home (-.1880)
Presence of disability or limiting illness (-.3578)	Vandalism index of dwelling (+.1347)	Vandalism index of dwelling (-.1321)
Relet work carried out in the last five years (-.2834)		Tenant's assessment of service from housing officer (+.1566)
		Council's response to repair need (+.2015)
50% of variations are explained	**13% of variations are explained**	**38% of variations are explained**

Fifty per cent of the variation in reactive maintenance cost were accounted for, 38% and 13% in satisfaction and property condition indices respectively. The lowly proportion of property condition explained by the group of significant variables finds explanation in the fact that this index is predominantly influenced by the intrinsic features of the dwelling building identified in chapters Six and Seven, but which do not lend themselves to interval or non-interval measurement within the property attribute group of variables.

Under the maintenance cost index, Presence of disability or limiting illness is the most influential variable, although with an inverse relationship (i.e. negative beta value). The reason for this lies in the fact that some items of maintenance in dwellings occupied by disabled persons are carried out under social service account rather than housing revenue account. The effect of this is to reduce maintenance spending by the housing department. The second most influential is tenant's age, and the third is relet work, which is an indicator of tenancy turnover. It is interesting that the fourth, length lived in current home, has a positive correlation. This means that the longer the tenant has lived in his or her dwelling, the higher the maintenance spending will be.

Under the property condition index, tenant's age is negatively related to property condition, i.e. the older the tenant, the poorer the property condition. The reason for this is that older people tend to show more preference for older properties, as they often believe they are less defect prone. This also explains the direction of variable, length lived in last home as older people would more probably have lived longer in a previous address. The positive beta sign of vandalism on property condition implies that the higher the level of vandalism associated with a dwelling, the more attractive the property condition appears to be. This suggests that housing management team respond positively to rectify vandalistic damage, thus resulting in some face-lift to property, or that dwellings preference by younger families with whom vandalism tends to be more frequent present more attractive facade as they are generally of newer construction.

Under tenant's satisfaction index, it is interesting that tenants opinions of their housing officer in particular and the council in general are positively related to how satisfied they are with repair works. This is to be expected as tenants who consider works carried out on their properties satisfactory would equally view the housing office as efficient. In the same vein, those who plan to move from their current home are less satisfied. It would appear that the desire to move is predicated by lack of satisfaction rather than for other reasons. It is however intriguing that vandalism index is negatively and significantly related to tenant's satisfaction. This does not support the theoretical notion (Ward, 1973) that vandalism is almost always inherent in the built form. Hence, the need for the construction of a vandalism index which sought to incorporate some elements of vandalism inherent in the tenant along with environmental vandalism.

Combining and comparing this group of factors with building object specific factors of chapters Six and Seven, it is most interesting that none of the nine variables in Table 9.3 belong to internal attributes of building property. Most building object specific factors as detected in chapter Seven do not afford ready measurement and may not have been included in the original 20 variables of chapter Eight safe in respect of property age. The aspect of vandalism in the regression model does not in fact share exactly the same features as that which is inherent in the building object, but more with the environment and individuals living in it. In essence, there are two dimensions to vandalism. According to Newman (1972) one of it is inherent in the nature of the built form. While the other is dictated by the social attitude of the individuals who live in it and their impact upon the immediate environment

9.2 Final Conclusion

The research has shown that building surveyors involved in the diagnosis and prognosis of defects should consider the causes of defects found in buildings as a starting point for remedial action. By sampling building surveyors from a specified survey population, the research has established that the factors involved in a specific component defect in local authority housing are often a combination of factors. It also demonstrates that each of the specific factors namely; age, construction, design, changing standard and vandalism affects some components more profoundly than others. The result is that the elimination of defect causes by surveyors is simplified depending on which component exhibits defect.

By sampling housing tenants of the local authority chosen for the study, it was revealed that the influence of tenant's attributes is very strong upon maintenance requirements. It revealed that it is insufficient for maintenance managers to base their understanding of the subject purely on physical characteristics and attributes of the property itself. Managers must also build into any budgetary prediction an allowance for variations in tenant profiles and their effects upon maintenance generation.

The research also found that housing management responsiveness to repair needs and report is a significant factor in maintenance need profile of Manchester Council housing stock. The research has therefore provided a collection of factors in the realm of the building object, tenants characteristics, housing management and environmental influence which have significant impact on maintenance need. These factors are identified as follows in Table 9.4.

Table 9.4: Factorial listing confirming the research hypotheses

Factors relating to Internal attributes of building	**Housing management responsiveness**	**Tenant's characteristics**	**Factors relating to the Environment**
Dwelling external influence	Tenant's assessment of service from housing office	Tenant's age	Vandalism index of dwelling
Design integrity standard of dwelling		Presence of disability or limiting illness	
Tenant's lack of care index		Relet work carried out on property in the last five years	
Influence of changing and evolving standard	Council's response to repair need	Vandalism index of dwelling	
Ageing influence		Length lived in last home	Dwelling orientation and soil condition
Vandalism - Design pull effect		Length lived in current home	
Design - construction inadequacy			
Accidental damage restricted to building envelope		Likelihood of moving from present home	
Dwelling orientation and soil condition			

9.3 Scope and limitations

The mediatory role of the stockholder is essentially discounted in this study - policy and budget matters are nebulous and do not readily lend themselves to direct and objective assessment, and for which no proxy variables have been devised. They are principally dictated by political dictum and nuances which are a function of national and international political and economic climate. Furthermore, no proportional strengths of the indices of maintenance need are inferred in the study and hence, does not confirm to what extent one variable is more or less important than the other. No account is taken of the realism of repairs carried out without defects having occurred as in preventive maintenance safe to the extent that such works (prior to painting repairs and external painting) are incorporated into the property condition index.

9.4 Recommendation for further study

The following issues which emerged but could not be covered in the course of this work are recognised as worthy of further investigation.

1. Further study can be conducted to establish more objective interval level measurement criteria for variables measured on a rating scale and classified as ordinal variables in the research such as level of disability of tenant, housing management responsiveness to repairs and building object features. Such interval level measurement would enable the effects of these variables to be more precisely investigated in a regression model.
2. This study can be replicated on additional public sector housing across the UK and elsewhere using the methodology described so that the results can be pooled and more dependable factorial framework can be developed.
3. It is recognised that this study does not constitute an end in its own right, it is only a means towards the development of comprehensive and appropriate maintenance forecasting models in the sector, for which a comprehensive and measurable list of significant factors are indispensable (Sanders and Thomas, 1992).

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APPENDIX 1AA

PRELIMINARY QUESTIONNAIRE ON FACTORS

1 **Professsion:** **Housing Management**

2. How long have you worked with M.C.C. in housing management capacity?

3. How many houses are there in the parcel(s) that you manage?

4. From your experience, do you think there is any difference in your attitude to actioning defect schedules towards the end of the financial year:

Yes No

5. Listed below are factors which we feel may have some bearing on the maintenance requirement of a dwelling unit. Please rank each of the factors according to the following criteria.

Very important 1
Important 2
Not so important 3

Factors	Level of importance of factor
Dwelling type (high rise, low rise)	
Size of dwelling (No. of bedrooms, floor area)	
Design (Detailing, specifications, etc.)	
Form of construction (No fines, etc)	
Tenant's employment status	
Family size	
Household with children	
Presence of disable person	
Multiple occupation	
Level of personal care for dwelling	
Age of tenant	
Household income level	
Difficult to satisfy tenant	
Right-by-buy opportunist tenant	
Stable tenant	
Orientation and exposure	
Vandalism in neighbourhood	
Age of property	
Changing standards	
Insufficient maintenance by council	
Council's response to maintenance	
Height of dwelling	
Location in terms of North or South	
Gender of tenant	
Turnover rate with tenant	
Nature of previous tenancy	
Duration of tenancy	

6. Do you feel that the cause of defects is important to you as a housing manager?

Yes No

APPENDIX 1AB

PRELIMINARY QUESTIONNAIRE ON FACTORS

1 **Professsion:** **Building Surveying**

2. How long have you worked with M.C.C. in Building surveyor capacity?

☐

3. Roughly, up to how many houses have you carried out surveys on in the last five years?

☐

4. From your experience, do you tend to have increased survey workload at the;

(a) beginning of the financial year

Yes ☐ No ☐

(b) end of the financial year

Yes ☐ No ☐

5. Listed below are factors which we feel may have some bearing on the maintenance requirement of a dwelling unit. Please rank each of the factors according to the following criteria.

Very important 1
Important 2
Not so important 3

Factors	Level of importance of factor
Dwelling type (high rise, low rise)	
Size of dwelling (No. of bedrooms, floor area)	
Design (Detailing, specifications, etc.)	
Form of construction (No fines, etc)	
Tenant's employment status	
Family size	
Household with children	
Presence of disable person	
Multiple occupation	
Level of personal care for dwelling	
Age of tenant	
Household income level	
Difficult to satisfy tenant	
Right-by-buy opportunist tenant	
Stable tenant	
Orientation and exposure	
Vandalism in neighbourhood	
Age of property	
Changing standards	
Insufficient maintenance by council	
Council's response to maintenance	
Height of dwelling	
Location in terms of North or South	
Gender of tenant	
Turnover rate with tenant	
Nature of previous tenancy	
Duration of tenancy	

6. Do you feel that the knowledge of factors responsible for causing defects is important the diagnosis of defects?

Yes ☐ No ☐

APPENDIX 1B

SURVEY QUESTIONNAIRE ON COUNCIL DWELLING MAINTENANCE NEED, IDENTIFICATION, MANAGEMENT AND RESPONSIBILITY - A STUDY OF MANCHESTER CITY COUNCIL HOUSING

NOTE ABOUT THE QUESTIONNAIRE

Please be assured that your identity will remain strictly confidential and that all information supplied is strictly for academic purposes and has nothing to do with any statutory rights and obligations.

As is the case with many, if not all surveys, there may be some questions which appear to be irrelevant or unimportant. Nonetheless, it is necessary in this study that all questions are answered, as the questionnaire is designed to achieve particular research objectives, and it is hoped not to offend respondents in any way whatsoever. However, if there are questions which you are unwilling or unable to answer, then it is my wish that you continue to answer the rest of the questionnaire.

GENERAL INFORMATION

Please tick the appropriate boxes

OFFICE USE ONLY

Q1 Please state your current job title:

☐ 1 Building surveyor

☐ 2 Compliance Officer

☐ 3 Senior Building Surveyor

☐ 4 Principal Surveyor

☐ 5 Surveying Manager

Please specify if any other _ ______________________

Q2 How long have you worked with Manchester City Council?

☐ 1 Less than 1 year

☐ 2 1 - 5 years

☐ 3 6 - 10 years

☐ 4 11 - 15 years

☐ 5 16 - 20 years

☐ 6 More than 20 years

Q3 How long have you worked with your present local Technical Department?

☐ 1 Less than 1 year

☐ 2 1 - 5 years

☐ 3 6 - 10 years

INFORMATION ON CAUSES OF DEFECTS

Q4 From your experience with the housing stock, please rate the frequency of defects on each of the five defect causes on a scale of 0 to 4:
0 for HARDLY EVER; 1 for VERY OCCASIONAL;
2 for OCCASIONAL; 3 for FREQUENT and;
4 for VERY FREQUENT

(a) Design fault
(b) Construction fault
(c) Age
(d) Changing standard
(e) Vandalism

/continued

	(a) Design fault	(b) Construction fault	(c) Age	(d) Changing Standard	(e) Vandalism
Damp proofing					
Defective roof structure					
Dry/wet rot					
Water ingress					
Burst pipe / broken sanitary appliance					
Reglazing					
Patch repairs to roof					
Damaged rainwater goods					
Lead flashing to bays, canopies or chimney stack					
Electrical faults					
Gas leakage					
Combating condensation					
Damaged security door					
Fencing replacement					
Blocked drain					
Removing graffiti					
Boiler replacement or repair to central heating					

Repairs / replacement to internal door					
Soil stacks in high rise					
Balcony concrete repairs					
Work to lift / motor					
External storey panels					
Backflow in soil pipes					
Expansion cracks					
Spalled bricks					
Wall tie failure					
Slab / Screed failure					
Damp floors					

Q5 From the list of building component defects, rank each of the 28 items in order of how frequently occurring they are by assigning 1 to the most frequent, 2 to the next most frequent and so on up to 28.

Rank	Component defect
	Damp proofing
	Defective roof structure
	Dry/wet rot
	Water ingress
	Burst pipe / broken sanitary appliance
	Reglazing
	Patch repairs to roof
	Damaged rainwater goods
	Lead flashing to bays, canopies or chimney stack
	Electrical faults
	Gas leakage
	Combating condensation
	Damaged security door
	Fencing replacement
	Blocked drain
	Removing graffiti
	Boiler replacement or repair to central heating
	Repairs / replacement to internal door
	Soil stacks in high rise
	Balcony concrete repairs
	Work to lift / motor
	External storey panels
	Backflow in soil pipes
	Expansion cracks
	Spalled bricks
	Wall tie failure
	Slab / Screed failure
	Damp floors

Thank you for sparing your precious time to attend to this questionnaire.

APPENDIX 1C

SURVEY ABOUT MAINTENANCE IN MANCHESTER COUNCIL HOUSING: ITS IDENTIFICATION AND MANAGEMENT

About this survey

Thank you for taking the trouble to look at these questions. The answers you provide will be used for academic research into Manchester Council house repairs. Your identity and address will be kept strictly confidential and the information you give will only be used for study purposes. Nothing you write will affect the service you get from Manchester City Council or your rights as a tenant.

Some of the questions might seem irrelevant or unimportant - but they will help the research. I hope you will answer them all, or at least as many as you feel you can.

Finally, I am afraid that the answers you give don't mean that the Council has plans to provide repairs or services based on individual problems. But by answering the questions you will be helping to bring in the kind of improvements in the repairs service that we all want to see.

It will be greatly appreciated if you would return the completed questionnaire within 2-3 weeks using the stamped addressed envelope provided.

August 1994.

1. How long have you lived in your current home?

2. How big a problem are the following issues in your area?

	Yes - a big Problem	Yes - a slight Problem	Not really a Problem	No trouble at all	Don't Know
Noise					
Car theft / breaking into cars					
Litter					
Graffiti					
Empty properties					
Vandalism					

Do you consider your home to be?

Very Satisfactory		4
Satisfactory		3
Unsatisfactory		2
Very Unsatisfactory		1
Don't know		9

4. How likely are you to move from your current home?

Very likely		4
Likely		3
Unlikely		2
Very Unlikely		1
Don't know		9

5. How long did you live at your last home?

Repair problems at your current home

6. Within the past 5 years how often have you reported the following?

Repairs	Over 5 times	2 - 5 times	Once	Never	Don't know
Electrical faults					
Gas leakage					
Heating faulty or damaged					
Drains blocked					
Leaking pipes / sanitary appliance					
Condensation					
Rising dampness					
Dry / wet rot					
Water penetration					
Internal doors faulty or damaged					
Window panes broken or damaged					
Windows rotting or damaged					
Fence / hedge broken or damaged					
Roof structure faulty					
Flashing faulty or damaged					
Roof tiles missing or faulty					
Rainwater goods leaking or faulty					
Cracked walls or ceiling					
Brickwork faulty or damaged					
Wall ties faulty					
Security door damaged					
Gate damaged					

7. Were you satisfied with the way the council dealt with your repairs

Repairs	Very satisfied	Satisfied	Fairly satisfied	Un-Satisfied	Don't know
Electrical faults					
Gas leakage					

Heating faulty or damaged					
Drains blocked					
Leaking pipes / sanitary appliance					
Condensation					
Rising dampness					
Dry / wet rot					
Water penetration					
Internal doors faulty or damaged					
Window panes broken or damaged					
Windows rotting or damaged					
Fence / hedge broken or damaged					
Roof structure faulty					
Flashing faulty or damaged					
Roof tiles missing or faulty					
Rainwater goods leaking or faulty					
Cracked walls or ceiling					
Brickwork faulty or damaged					
Wall ties faulty					
Security door damaged					
Gate damaged					

8. How likely are you to carry out these repairs yourself?

Repairs	Very likely	Likely	Unlikely	Very Unlikely	Don't know
Electrical faults					
Gas leakage					
Heating faulty or damaged					
Drains blocked					
Leaking pipes / sanitary appliance					
Condensation					
Rising dampness					
Dry / wet rot					
Water penetration					
Internal doors faulty or damaged					
Window panes broken or damaged					
Windows rotting or damaged					
Fence / hedge broken or damaged					
Roof structure faulty					
Flashing faulty or damaged					
Roof tiles missing or faulty					
Rainwater goods leaking or faulty					
Cracked walls or ceiling					
Brickwork faulty or damaged					
Wall ties faulty					
Security door damaged					
Gate damaged					

9. How do you think the council respond to the following issues?

	Very well	Well	Bad	Very bad	Don't know
Repairs					
Vandalism (in the neighbourhood)					
Nuisance (in the neighbourhood)					

10. Do you think the service you receive from your housing office is :

Very good	☐	4
Good	☐	3
Poor	☐	2
Very poor	☐	1
Don't know	☐	9

11. Have you considered exercising your Right-To-Buy your own home?

Already applying	☐	5
Still considering	☐	4
Considered it but don't want to buy	☐	3
May consider it one day	☐	2
Never would consider it	☐	1
Don't know	☐	9

12. Please give a brief reason for your answer to question 11.

____

____

13. Which of the following statements best describes you?

I report repairs immediately no matter how small	☐	5
I take my time in reporting repairs which I consider not very serious	☐	4
I would rather fix minor repairs myself	☐	3
I only report repairs if it is a threat to my family's or my own health	☐	2
I never report repairs	☐	1
Don't know	☐	9

14. Are you:

Male	☐	1
Female	☐	2

15. Are you:

Single adult without children		1
Single adult with children		2
2 or more adults without children		3
2 or more adults with children		4

16. If you have children living with you, how many in the following age groups?

0 - 2 years	
3 - 6 years	
7 - 12 years	
Over 12 years	

17. How old are you?

16 - 30 years	
31 - 45 years	
46 - 65 years	
Over 65 years	

18. Are you or your partner:

	You	You partner
Employed full time		
Employed part time		
Unemployed		
In full time education		
Retired		

19. If employed, what is the nature of your job?

You ____________________________

Your partner ____________________________

20. Is any of your household disabled or have any limiting illness?

Yes		1
No		2

APPENDIX 2A

DESIGN MODEL EQUATION

* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. GENRANK Overall rank among surveyor

Block Number 1. Method: Enter DESIGN

Variable(s) Entered on Step Number
1.. DESIGN ranking of mean scores on design

Multiple R	.43514
R Square	.18935
Adjusted R Square	.15817
Standard Error	7.54745

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	345.93596	345.93596
Residual	26	1481.06404	56.96400

F = 6.07289 Signif F = .0207

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DESIGN	.435140	.176576	.435140	2.464	.0207
(Constant)	8.190476	2.930838		2.795	.0096

End Block Number 1 All requested variables entered.

Age model equation

**** MULTIPLE REGRESSION ****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. GENRANK Overall rank among surveyo

Block Number 1. Method: Enter AGE

Variable(s) Entered on Step Number
1.. AGE ranking of mean scores on age

Multiple R	.04269
R Square	.00182
Adjusted R Square	-.03657
Standard Error	8.37503

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	3.33005	3.33005
Residual	26	1823.66995	70.14115

F = .04748 Signif F = .8292

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
AGE	.042693	.195937	.042693	.218	.8292
(Constant)	13.880952	3.252205		4.268	.0002

End Block Number 1 All requested variables entered.

Standard model equation

* * * * M U L T I P L E R E G R E S S I O N * * * *

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. GENRANK1 transformed genrank

Block Number 1. Method: Enter STANDRD1

Variable(s) Entered on Step Number
1.. STANDRD1

Multiple R	.34419
R Square	.11847
Adjusted R Square	.08456
Standard Error	8.54928

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	16418.95643	16418.95643
Residual	26	122174.08552	4699.00329

F = 3.49414 Signif F = .0729

----------------- Variables in the Equation -----------------

Variable	B	SE B	Beta	T	Sig T
STANDRD1	.344193	.184133	.344193	1.869	.0729
(Constant)	166.895941	48.617664		3.433	.0020

Construction model equation

* * * *   M U L T I P L E   R E G R E S S I O N   * * * *

Listwise Deletion of Missing Data

Equation Number 1   Dependent Variable..   GENRANK   Overall rank among surveyo

Block Number 1. Method: Enter   CONSTRUT

Variable(s) Entered on Step Number
1..   CONSTRUT ranking of mean score on construction

Multiple R	.46009
R Square	.21168
Adjusted R Square	.18137
Standard Error	7.44273

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	386.74826	386.74826
Residual	26	1440.25174	55.39430

F =   6.98173   Signif F = .0138

----------------- Variables in the Equation -----------------

Variable	B	SE B	Beta	T	Sig T
CONSTRUT	.459594	.173937	.460092	2.642	.0138
(Constant)	7.852303	2.882362		2.724	.0114

Vandalism model equation

**** M U L T I P L E   R E G R E S S I O N ****

Listwise Deletion of Missing Data

Equation Number 1   Dependent Variable..   GENRANK1   transformed genrank

Block Number 1. Method: Enter   VANDAL1

Variable(s) Entered on Step Number
1..   VANDAL1

Multiple R	.13994
R Square	.01958
Adjusted R Square	-.01813
Standard Error	72.29190

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2713.96809	2713.96809
Residual	26	135879.07385	5226.11823

F =   .51931   Signif F = .4776

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
VANDAL1	-.139937	.194186	-.139937	-.721	.4776
(Constant)	290.101837	51.272067		5.658	.0000

APPENDIX 3.1

CORRELATIONS BETWEEN EACH OF THE SIX CRITERIA ON VANDALISM INDEX

NOISPROB noise problem in area by CARPROB car theft problem in area

CARPROB — Page 1 of 1

Count / NOISPROB	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al	21	7	7	6	41 25,8
2 not really a pro	6	10	12	13	41 25,8
3 a slight problem	2	7	16	14	39 24,5
4 a big problem	1	4	7	26	38 23,9
Column Total	30 18,9	28 17,6	42 26,4	59 37,1	159 100,0

Chi-Square	Value	DF	Significance
Pearson	56,01772	9	,00000
Likelihood Ratio	53,00409	9	,00000
Mantel-Haenszel test for linear association	39,25079	1	,00000

Minimum Expected Frequency - 6,692

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,42401	,05946	7,06677	
Pearson's R	,49842	,06355	7,20375	,00000 *4
Spearman Cofrelation	,48818	,06627	7,00874	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 93

LITAPROB litter problem in area by CARPROB car theft problem in area

CARPROB Page 1 of 1

Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
LITAPROB					
1 no trouble at al	19	3		3	25 15,6
2 not really a pro	4	9	8	6	27 16,9
3 a slight problem	7	12	22	18	59 36,9
4 a big problem	2	3	13	31	49 30,6
Column Total	32 20,0	27 16,9	43 26,9	58 36,3	160 100,0

Chi-Square	Value	DF	Significance
Pearson	81,28717	9	,00000
Likelihood Ratio	74,71645	9	,00000
Mantel-Haenszel test for linear association	49,90103	1	,00000

Minimum Expected Frequency - 4,219
Cells with Expected Frequency < 5 - 2 OF 16 (12,5%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,46825	,06043	7,51956	
Pearson's R	,56022	,06480	8,50106	,00000 *4
Spearman Correlation	,52672	,06608	7,78870	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 92

GRAFPROB graffitti problem in area by CARPROB car theft problem in area

GRAFPROB (Count)	CARPROB 1 no trouble at al	2 not really a pro	3 a slight problem	4 a big problem	Row Total
1 no trouble at al	23	9	6	13	51 34,7
2 not really a pro	6	13	20	15	54 36,7
3 a slight problem	1	3	10	12	26 17,7
4 a big problem			3	13	16 10,9
Column Total	30 20,4	25 17,0	39 26,5	53 36,1	147 100,0

Page 1 of 1

Chi-Square	Value	DF	Significance
Pearson	49,66003	9	,00000
Likelihood Ratio	52,35710	9	,00000
Mantel-Haenszel test for linear association	31,81589	1	,00000

Minimum Expected Frequency - 2,721
Cells with Expected Frequency < 5 - 4 OF 16 (25,0%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,39666	,06422	6,00416	
Pearson's R	,46682	,06184	6,35628	,00000 *4
Spearman Correlation	,44454	,07243	5,97593	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 105

EMPTPROB empty property problem in area by CARPROB car theft problem in area

CARPROB — Page 1 of 1

Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
EMPTPROB					
1 no trouble at al	23	6	6	13	48 35,6
2 not really a pro	4	13	15	10	42 31,1
3 a slight problem	2	3	8	10	23 17,0
4 a big problem		2	7	13	22 16,3
Column Total	29 21,5	24 17,8	36 26,7	46 34,1	135 100,0

Chi-Square	Value	DF	Significance
Pearson	43,27706	9	,00000
Likelihood Ratio	44,87486	9	,00000
Mantel-Haenszel test for linear association	23,17993	1	,00000

Minimum Expected Frequency - 3,911
Cells with Expected Frequency < 5 - 4 OF 16 (25,0%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,34953	,07016	4,91606	
Pearson's R	,41591	,07041	5,27440	,00000 *4
Spearman Correlation	,39529	,07947	4,96284	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 117

VANDPROB empty property problem in area by CARPROB car theft problem in area

CARPROB Page 1 of 1

Count VANDPROB	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al	22	7	4	7	40 25,5
2 not really a pro	5	12	15	6	38 24,2
3 a slight problem	4	4	17	13	38 24,2
4 a big problem		2	6	33	41 26,1
Column Total	31 19,7	25 15,9	42 26,8	59 37,6	157 100,0

Chi-Square	Value	DF	Significance
Pearson	88,12734	9	,00000
Likelihood Ratio	86,45847	9	,00000
Mantel-Haenszel test for linear association	56,15636	1	,00000

Minimum Expected Frequency - 6,051

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,53213	,05651	9,33356	
Pearson's R	,59998	,05810	9,33695	,00000 *4
Spearman Correlation	,59568	,06094	9,23291	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 95

NOISPROB noise problem in area by GRAFPROB graffitti problem in area

GRAFPROB Page 1 of 1

Count / NOISPROB	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al	29	12	3		44 27,7
2 not really a pro	11	21	9	3	44 27,7
3 a slight problem	8	18	9	3	38 23,9
4 a big problem	10	5	7	11	33 20,8
Column Total	58 36,5	56 35,2	28 17,6	17 10,7	159 100,0

Chi-Square	Value	DF	Significance
Pearson	48,54380	9	,00000
Likelihood Ratio	47,79126	9	,00000
Mantel-Haenszel test for linear association	25,90742	1	,00000

Minimum Expected Frequency - 3,528
Cells with Expected Frequency < 5 - 4 OF 16 (25,0%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,34229	,06704	5,03764	
Pearson's R	,40493	,07210	5,54910	,00000 *4
Spearman Correlation	,38715	,07527	5,26130	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 93

LITAPROB litter problem in area by GRAFPROB graffitti problem in area

GRAFPROB Page 1 of 1

Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
LITAPROB					
1 no trouble at al	28				28 17,0
2 not really a pro	7	20	2		29 17,6
3 a slight problem	17	22	15	2	56 33,9
4 a big problem	8	14	12	18	52 31,5
Column Total	60 36,4	56 33,9	29 17,6	20 12,1	165 100,0

Chi-Square	Value	DF	Significance
Pearson	102,82896	9	,00000
Likelihood Ratio	107,64658	9	,00000
Mantel-Haenszel test for linear association	55,17735	1	,00000

Minimum Expected Frequency - 3,394
Cells with Expected Frequency < 5 - 3 OF 16 (18,8%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,51102	,05218	9,27681	
Pearson's R	,58004	,04782	9,09106	,00000 *4
Spearman Correlation	,56882	,05785	8,82980	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 87

EMPTPROB empty property problem in area
by GRAFPROB graffitti problem in area

GRAFPROB Page 1 of 1

Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
EMPTPROB					
1 no trouble at al	41	8	7		56 39,7
2 not really a pro	7	25	8	1	41 29,1
3 a slight problem	3	8	10	2	23 16,3
4 a big problem	1	8	2	10	21 14,9
Column Total	52 36,9	49 34,8	27 19,1	13 9,2	141 100,0

Chi-Square	Value	DF	Significance
Pearson	98,97627	9	,00000
Likelihood Ratio	88,37040	9	,00000
Mantel-Haenszel test for linear association	49,73097	1	,00000

Minimum Expected Frequency - 1,936
Cells with Expected Frequency < 5 - 5 OF 16 (31,3%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,53727	,06111	8,64176	
Pearson's R	,59600	,06299	8,75088	,00000 *4
Spearman Correlation	,59836	,06435	8,80480	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 111

VANDPROB empty property problem in area
by GRAFPROB graffitti problem in area

GRAFPROB Page 1 of 1

Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
VANDPROB					
1 no trouble at al	42	2			44 27,0
2 not really a pro	6	28	5		39 23,9
3 a slight problem	8	16	13		37 22,7
4 a big problem	3	8	12	20	43 26,4
Column Total	59 36,2	54 33,1	30 18,4	20 12,3	163 100,0

Chi-Square	Value	DF	Significance
Pearson	164,30807	9	,00000
Likelihood Ratio	164,21226	9	,00000
Mantel-Haenszel test for linear association	87,47476	1	,00000

Minimum Expected Frequency - 4,540
Cells with Expected Frequency < 5 - 2 OF 16 (12,5%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,67526	,04470	14,62872	
Pearson's R	,73482	,04092	13,74683	,00000 *4
Spearman Correlation	,73870	,04577	13,90594	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 89

NOISPROB noise problem in area by EMPTPROB empty property problem in area

EMPTPROB Page 1 of 1

NOISPROB	Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al		26	11	4	1	42 29,2
2 not really a pro		12	19	7	3	41 28,5
3 a slight problem		7	10	6	7	30 20,8
4 a big problem		10	4	4	13	31 21,5
Column Total		55 38,2	44 30,6	21 14,6	24 16,7	144 100,0

Chi-Square	Value	DF	Significance
Pearson	37,44543	9	,00002
Likelihood Ratio	37,20348	9	,00002
Mantel-Haenszel test for linear association	21,78071	1	,00000

Minimum Expected Frequency - 4,375
Cells with Expected Frequency < 5 - 2 OF 16 (12,5%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,32392	,07060	4,54246	
Pearson's R	,39027	,07721	5,05120	,00000 *4
Spearman Correlation	,36658	,07997	4,69515	,00001 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 108

LITAPROB litter problem in area by EMPTPROB empty property problem in area

EMPTPROB Page 1 of 1

Count	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
LITAPROB					
1 no trouble at al	23		1		24 16,1
2 not really a pro	6	15	1	1	23 15,4
3 a slight problem	19	19	12	7	57 38,3
4 a big problem	9	10	10	16	45 30,2
Column Total	57 38,3	44 29,5	24 16,1	24 16,1	149 100,0

Chi-Square	Value	DF	Significance
Pearson	67,00428	9	,00000
Likelihood Ratio	69,88902	9	,00000
Mantel-Haenszel test for linear association	36,09881	1	,00000

Minimum Expected Frequency - 3,705
Cells with Expected Frequency < 5 - 4 OF 16 (25,0%)

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,42833	,05997	6,89775	
Pearson's R	,49387	,05839	6,88633	,00000 *4
Spearman Correlation	,48217	,06709	6,67286	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 103

VANDPROB empty property problem in area
by EMPTPROB empty property problem in area

Count	EMPTPROB no troub le at al 1	not real ly a pro 2	a slight problem 3	a big pr oblem 4	Row Total
VANDPROB					Page 1 of 1
1 no trouble at al	32	3	3	1	39 26,5
2 not really a pro	5	24	3	3	35 23,8
3 a slight problem	13	13	10		36 24,5
4 a big problem	6	3	8	20	37 25,2
Column Total	56 38,1	43 29,3	24 16,3	24 16,3	147 100,0

Chi-Square	Value	DF	Significance
Pearson	111,14964	9	,00000
Likelihood Ratio	105,37492	9	,00000
Mantel-Haenszel test for linear association	44,64060	1	,00000

Minimum Expected Frequency - 5,714

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,48778	,06710	7,17320	
Pearson's R	,55295	,06820	7,99129	,00000 *4
Spearman Correlation	,54180	,07179	7,76205	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 105

NOISPROB noise problem in area by VANDPROB empty property problem in area

VANDPROB Page 1 of 1

NOISPROB (Count)	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al	26	9	9	1	45 25,3
2 not really a pro	9	14	13	11	47 26,4
3 a slight problem	7	11	12	13	43 24,2
4 a big problem	7	6	6	24	43 24,2
Column Total	49 27,5	40 22,5	40 22,5	49 27,5	178 100,0

Chi-Square	Value	DF	Significance
Pearson	48,93491	9	,00000
Likelihood Ratio	50,77910	9	,00000
Mantel-Haenszel test for linear association	32,07587	1	,00000

Minimum Expected Frequency - 9,663

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,36902	,05845	6,33632	
Pearson's R	,42570	,06544	6,24130	,00000 *4
Spearman Correlation	,42941	,06635	6,30801	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 74

LITAPROB litter problem in area by VANDPROB empty property problem in area

LITAPROB / Count	VANDPROB: no trouble at all 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al	26		3	1	30 16,5
2 not really a pro	5	17	2	3	27 14,8
3 a slight problem	12	16	22	14	64 35,2
4 a big problem	6	7	14	34	61 33,5
Column Total	49 26,9	40 22,0	41 22,5	52 28,6	182 100,0

Page 1 of 1

Chi-Square	Value	DF	Significance
Pearson	114,39285	9	,00000
Likelihood Ratio	104,88739	9	,00000
Mantel-Haenszel test for linear association	59,34170	1	,00000

Minimum Expected Frequency - 5,934

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,50186	,05429	9,06570	
Pearson's R	,57259	,05667	9,37012	,00000 *4
Spearman Correlation	,56148	,05860	9,10353	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 70

NOISPROB noise problem in area by LITAPROB litter problem in area

LITAPROB — Page 1 of 1

Count (NOISPROB)	no trouble at al 1	not really a pro 2	a slight problem 3	a big problem 4	Row Total
1 no trouble at al	20	5	13	7	45 23,9
2 not really a pro	2	18	18	14	52 27,7
3 a slight problem	4	6	24	10	44 23,4
4 a big problem	3	3	8	33	47 25,0
Column Total	29 15,4	32 17,0	63 33,5	64 34,0	188 100,0

Chi-Square	Value	DF	Significance
Pearson	81,46167	9	,00000
Likelihood Ratio	72,01010	9	,00000
Mantel-Haenszel test for linear association	34,95545	1	,00000

Minimum Expected Frequency - 6,787

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,38239	,06073	6,25303	
Pearson's R	,43235	,06712	6,53926	,00000 *4
Spearman Correlation	,43261	,06716	6,54415	,00000 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 64

APPENDIX 3.2

CONSISTENCY OF VANDALISM INDEX ALONG LOCATION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
M8 / M9	1	146	57,9	57,9	57,9
M22 / M23	3	106	42,1	42,1	100,0
	Total	252	100,0	100,0	

Valid cases 252 Missing cases 0

NOISPROB noise problem in area by LOCATION

LOCATION Page 1 of 1

NOISPROB (Count)	M8 / M9 1	M22 / M23 3	Row Total
1 no trouble at al	30	17	47 22,3
2 not really a pro	34	22	56 26,5
3 a slight problem	23	27	50 23,7
4 a big problem	34	24	58 27,5
Column Total	121 57,3	90 42,7	211 100,0

Chi-Square	Value	DF	Significance
Pearson	3,73748	3	,29124
Likelihood Ratio	3,71663	3	,29373
Mantel-Haenszel test for linear association	,81478	1	,36671

Minimum Expected Frequency - 20,047

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,05621	,06230	,90198	
Pearson's R	,06229	,06803	,90225	,36796 *4
Spearman Correlation	,06154	,06822	,89141	,37373 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 41

CARPROB car theft problem in area by LOCATION

LOCATION Page 1 of 1

CARPROB / Count	M8 / M9 1	M22 / M23 3	Row Total
1 no trouble at al	15	17	32 18,8
2 not really a pro	17	11	28 16,5
3 a slight problem	23	22	45 26,5
4 a big problem	43	22	65 38,2
Column Total	98 57,6	72 42,4	170 100,0

Chi-Square	Value	DF	Significance
Pearson	4,34266	3	,22676
Likelihood Ratio	4,35879	3	,22524
Mantel-Haenszel test for linear association	2,51283	1	,11292

Minimum Expected Frequency - 11,859

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	-,11708	,06972	-1,67961	
Pearson's R	-,12194	,07604	-1,59238	,11318 *4
Spearman Correlation	-,12735	,07581	-1,66418	,09794 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 82

GRAFPROB graffitti problem in area by LOCATION

GRAFPROB (Count)	LOCATION: M8 / M9 (1)	LOCATION: M22 / M23 (3)	Row Total
1 no trouble at al	37	23	60 35,5
2 not really a pro	32	25	57 33,7
3 a slight problem	20	10	30 17,8
4 a big problem	12	10	22 13,0
Column Total	101 59,8	68 40,2	169 100,0

Page 1 of 1

Chi-Square	Value	DF	Significance
Pearson	1,24516	3	,74220
Likelihood Ratio	1,25347	3	,74021
Mantel-Haenszel test for linear association	,04368	1	,83446

Minimum Expected Frequency - 8,852

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,01352	,07088	,19082	
Pearson's R	,01612	,07707	,20839	,83518 *4
Spearman Correlation	,01466	,07681	,18943	,84999 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 83

EMPTPROB empty property problem in area by LOCATION

EMPTPROB (Count)	LOCATION: M8 / M9 (1)	M22 / M23 (3)	Row Total
1 no trouble at al	35	22	57 37,5
2 not really a pro	21	23	44 28,9
3 a slight problem	18	7	25 16,4
4 a big problem	20	6	26 17,1
Column Total	94 61,8	58 38,2	152 100,0

Page 1 of 1

Chi-Square	Value	DF	Significance
Pearson	7,31849	3	,06241
Likelihood Ratio	7,43697	3	,05920
Mantel-Haenszel test for linear association	2,59499	1	,10720

Minimum Expected Frequency - 9,539

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	-,09969	,07180	-1,38303	
Pearson's R	-,13109	,07609	-1,61953	,10743 *4
Spearman Correlation	-,10834	,07811	-1,33476	,18398 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 100

VANDPROB empty property problem in area by LOCATION

LOCATION Page 1 of 1

VANDPROB (Count)	M8 / M9 1	M22 / M23 3	Row Total
1 no trouble at al	29	22	51 26,2
2 not really a pro	24	16	40 20,5
3 a slight problem	21	23	44 22,6
4 a big problem	40	20	60 30,8
Column Total	114 58,5	81 41,5	195 100,0

Chi-Square	Value	DF	Significance
Pearson	3,84383	3	,27883
Likelihood Ratio	3,84999	3	,27813
Mantel-Haenszel test for linear association	,53605	1	,46407

Minimum Expected Frequency - 16,615

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	-,05276	,06482	-,81423	
Pearson's R	-,05257	,07073	-,73128	,46550 *4
Spearman Correlation	-,05771	,07088	-,80305	,42293 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations:

LITAPROB litter problem in area by LOCATION

LITAPROB	Count	LOCATION M8 / M9 1	M22 / M23 3	Row Total	Page 1 of 1
1	no trouble at al	21	10	31 15,0	
2	not really a pro	23	10	33 15,9	
3	a slight problem	35	35	70 33,8	
4	a big problem	45	28	73 35,3	
	Column Total	124 59,9	83 40,1	207 100,0	

Chi-Square	Value	DF	Significance
Pearson	5,06112	3	,16738
Likelihood Ratio	5,07298	3	,16653
Mantel-Haenszel test for linear association	,84679	1	,35746

Minimum Expected Frequency - 12,430

Statistic	Value	ASE1	Val/ASE0	Approximate Significance
Kendall's Tau-b	,04441	,06294	,70480	
Pearson's R	,06411	,06756	,91987	,35872 *4
Spearman Correlation	,04816	,06828	,69031	,49078 *4

*4 VAL/ASE0 is a t-value based on a normal approximation, as is the significance

Number of Missing Observations: 45

APPENDIX 3.3

RELIABILITY ANALYSIS - SCALE (ALPHA)

Reliability Coefficients

N of Cases = 124,0 N of Items = 6

Alpha = ,8583

APPENDIX 3.4

T-TEST OF VANDALISM INDEX CRITERIA

t-tests for independent samples of LOCATION

Variable	Number of Cases	Mean	SD	SE of Mean
CARPROB car theft problem in area				
M8 / M9	98	2,9592	1,111	,112
M22 / M23	72	2,6806	1,149	,135

Mean Difference = ,2786

Levene's Test for Equality of Variances: F= ,593 P= ,442

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	1,59	168	,113	,175	(-,067; ,624)
Unequal	1,58	150,26	,115	,176	(-,069; ,626)

(t-test for Equality of Means)

Variable	Number of Cases	Mean	SD	SE of Mean
NOISPROB noise problem in area				
M8 / M9	121	2,5041	1,148	,104
M22 / M23	90	2,6444	1,074	,113

Mean Difference = -,1403

Levene's Test for Equality of Variances: F= 1,729 P= ,190

t-test for Equality of Means 95%

t-tests for independent samples of LOCATION

Variable	Number of Cases	Mean	SD	SE of Mean
LITAPROB litter problem in area				
M8 / M9	124	2,8387	1,100	,099
M22 / M23	83	2,9759	,975	,107

Mean Difference = -,1372

Levene's Test for Equality of Variances: F= 6,598 P= ,011

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-,90	209	,368	,156	(-,447; ,166)
Unequal	-,91	198,36	,363	,154	(-,444; ,163)

Variable	Number of Cases	Mean	SD	SE of Mean
GRAFPROB graffitti problem in area				
M8 / M9	101	2,0693	1,022	,102
M22 / M23	68	2,1029	1,039	,126

Mean Difference = -,0336

Levene's Test for Equality of Variances: F= ,003 P= ,953

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-,21	167	,835	,161	(-,352; ,285)
Unequal	-,21	142,34	,836	,162	(-,354; ,286)

t-tests for independent samples of LOCATION

Variable	Number of Cases	Mean	SD	SE of Mean
EMPTPROB empty property problem in area				
M8 / M9	94	2,2447	1,170	,121
M22 / M23	58	1,9483	,963	,126

Mean Difference = ,2964

Levene's Test for Equality of Variances: F= 10,962 P= ,001

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	1,62	150	,107	,183	(-,065; ,658)
Unequal	1,70	138,00	,092	,175	(-,049; ,642)

Variable	Number of Cases	Mean	SD	SE of Mean
VANDPROB vandalism problem in area				
M8 / M9	114	2,6316	1,207	,113
M22 / M23	81	2,5062	1,142	,127

Mean Difference = ,1254

Levene's Test for Equality of Variances: F= 1,159 P= ,283

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	,73	193	,465	,171	(-,213; ,464)
Unequal	,74	178,01	,461	,170	(-,210; ,461)

APPENDIX 3.5

Chi-square statistics on dwelling types for selected variables: MOVEPLAN, RESNUISE, RESREPIR, RESVANDL, HSGOFFS, REPIRATT, GENDER, TENAGE, DISABLE and LOCATION

MOVEPLAN likelihood of moving from present home by CLASS1 collapsed class

CLASS1 Page 1 of 1

MOVEPLAN (Count)		CLASS1 1.00	2.00	3.00	Row Total
very unlikely	1	19	40	41	100 44.8
unlikely	2	13	30	22	65 29.1
likely	3	8	13	7	28 12.6
very likely	4	8	14	8	30 13.5
Column Total		48 21.5	97 43.5	78 35.0	223 100.0

Chi-Square	Value	DF	Significance
Pearson	4.34209	6	.63049
Likelihood Ratio	4.35969	6	.62812
Mantel-Haenszel test for linear association	3.36548	1	.06658

Minimum Expected Frequency - 6.027

Number of Missing Observations: 29

RESNUISE council's response to nuisance by CLASS1 collapsed class

CLASS1 — Page 1 of 1

RESNUISE	Count	1.00	2.00	3.00	Row Total
very bad	1	13	14	15	42 16.8
bad	2	7	9	15	31 12.4
well	3	7	17	12	36 14.4
very well	4	4	5	2	11 4.4
don't know	9	21	62	47	130 52.0
	Column Total	52 20.8	107 42.8	91 36.4	250 100.0

Chi-Square	Value	DF	Significance
Pearson	10.27974	8	.24594
Likelihood Ratio	10.21548	8	.25023
Mantel-Haenszel test for linear association	.79316	1	.37315

Minimum Expected Frequency - 2.288
Cells with Expected Frequency < 5 - 3 OF 15 (20.0%)

Number of Missing Observations: 2

RESREPIR council's response to repair by CLASS1 collapsed class

CLASS1 Page 1 of 1

RESREPIR	Count	1.00	2.00	3.00	Row Total
very bad	1	6	7	10	23 9.1
bad	2	7	19	15	41 16.3
well	3	16	51	47	114 45.2
very well	4	15	24	16	55 21.8
don't know	9	8	6	3	17 6.7
	14		1		1 .4
	33	1			1 .4
	Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	19.62390	12	.07454
Likelihood Ratio	18.65594	12	.09718
Mantel-Haenszel test for linear association	8.62096	1	.00332

Minimum Expected Frequency - .210
Cells with Expected Frequency < 5 - 8 OF 21 (38.1%)

Number of Missing Observations: 0

RESVANDL council's response to vandalism by CLASS1 collapsed class

CLASS1 Page 1 of 1

RESVANDL	Count	1.00	2.00	3.00	Row Total
very bad	1	8	12	12	32 12.8
bad	2	9	12	15	36 14.4
well	3	7	13	13	33 13.2
very well	4	3	3	2	8 3.2
don't know	9	25	67	49	141 56.4
	Column Total	52 20.8	107 42.8	91 36.4	250 100.0

Chi-Square	Value	DF	Significance
Pearson	4.88682	8	.76960
Likelihood Ratio	4.75093	8	.78384
Mantel-Haenszel test for linear association	.07914	1	.77847

Minimum Expected Frequency - 1.664
Cells with Expected Frequency < 5 - 3 OF 15 (20.0%)

Number of Missing Observations: 2

HSGOFFS assessment of service from housing offic by CLASS1 collapsed class

CLASS1 Page 1 of 1

HSGOFFS	Count	1.00	2.00	3.00	Row Total
very poor	1	5	7	13	25 9.9
poor	2	9	22	15	46 18.3
good	3	18	46	36	100 39.7
very good	4	12	23	10	45 17.9
don't know	9	9	10	17	36 14.3
Column Total		53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	11.39314	8	.18040
Likelihood Ratio	11.81689	8	.15956
Mantel-Haenszel test for linear association	.00102	1	.97450

Minimum Expected Frequency - 5.258

Number of Missing Observations: 0

REPIRATT attitude to repair problems by CLASS1 collapsed class

CLASS1 — Page 1 of 1

REPIRATT (Count)	1.00	2.00	3.00	Row Total
1 I only repairs -	12	20	13	45 18.1
2 I would rather f	8	28	21	57 22.9
3 I take time in r	13	20	31	64 25.7
4 I report repairs	19	40	24	83 33.3
Column Total	52 20.9	108 43.4	89 35.7	249 100.0

Chi-Square	Value	DF	Significance
Pearson	9.80917	6	.13292
Likelihood Ratio	9.94353	6	.12705
Mantel-Haenszel test for linear association	.00145	1	.96965

Minimum Expected Frequency - 9.398

Number of Missing Observations: 3

GENDER by CLASS1 collapsed class

CLASS1 Page 1 of 1

GENDER	Count	1.00	2.00	3.00	Row Total
male	1	27	58	38	123 48.8
female	2	26	50	53	129 51.2
	Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	2.94280	2	.22960
Likelihood Ratio	2.95298	2	.22844
Mantel-Haenszel test for linear association	1.64237	1	.20000

Minimum Expected Frequency - 25.869

Number of Missing Observations: 0

TENAGE tenant's age by CLASS1 collapsed class

CLASS1 Page 1 of 1

TENAGE (Count)	1.00	2.00	3.00	Row Total
1 16 - 30 years	5	18	7	30 11.9
2 31 - 45	7	12	17	36 14.3
3 46 - 65	15	23	24	62 24.6
4 over 65 years	26	55	43	124 49.2
Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	6.74754	6	.34483
Likelihood Ratio	6.69681	6	.34980
Mantel-Haenszel test for linear association	.00979	1	.92117

Minimum Expected Frequency - 6.310

Number of Missing Observations: 0

DISABLE presence of disability or limiting illne by CLASS1 collapsed class

CLASS1 Page 1 of 1

DISABLE	Count	1.00	2.00	3.00	Row Total
yes	1	9	30	27	66 26.5
no	2	43	76	64	183 73.5
	Column Total	52 20.9	106 42.6	91 36.5	249 100.0

Chi-Square	Value	DF	Significance
Pearson	2.90175	2	.23436
Likelihood Ratio	3.09911	2	.21234
Mantel-Haenszel test for linear association	2.19299	1	.13864

Minimum Expected Frequency - 13.783

Number of Missing Observations: 3

LOCATION by CLASS1 collapsed class

CLASS1 — Page 1 of 1

LOCATION	Count	1.00	2.00	3.00	Row Total
M8 / M9	1	45	59	42	146 57.9
M22 / M23	3	8	49	49	106 42.1
	Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	21.48673	2	.00002
Likelihood Ratio	23.58345	2	.00001
Mantel-Haenszel test for linear association	18.49777	1	.00002

Minimum Expected Frequency - 22.294

Number of Missing Observations: 0

RTBCOMP COMPRESSED RTB by CLASS1 collapsed class

CLASS1 — Page 1 of 1

RTBCOMP (Count)	CLASS1 1.00	2.00	3.00	Row Total
1.0	47	85	60	192 81.4
2.0	5	13	26	44 18.6
Column Total	52 22.0	98 41.5	86 36.4	236 100.0

Chi-Square	Value	DF	Significance
Pearson	12.27800	2	.00216
Likelihood Ratio	12.00101	2	.00248
Mantel-Haenszel test for linear association	10.60158	1	.00113

Minimum Expected Frequency - 9.695

Number of Missing Observations: 16

CHILDCT Number of children in dwelling by CLASS1 collapsed class

CLASS1 Page 1 of 1

CHILDCT (Count)	1.00	2.00	3.00	Row Total
1 No child present	53	82	58	193 76.6
2 one or more chil		26	33	59 23.4
Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	24.60968	2	.00000
Likelihood Ratio	35.87152	2	.00000
Mantel-Haenszel test for linear association	23.33920	1	.00000

Minimum Expected Frequency - 12.409

Number of Missing Observations: 0

RELET1 by CLASS1 collapsed class

CLASS1 — Page 1 of 1

RELET1	Count	1.00	2.00	3.00	Row Total
yes	1	11	17	4	32 12.7
no	2	42	91	87	220 87.3
	Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Chi-Square	Value	DF	Significance
Pearson	9.66340	2	.00797
Likelihood Ratio	10.84332	2	.00442
Mantel-Haenszel test for linear association	9.08669	1	.00257

Minimum Expected Frequency - 6.730

Number of Missing Observations: 0

APPENDIX 3.6

Crosstab of property types between North and South areas

CLASS1 collapsed class

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
High rise flat	1	53	21.0	21.0	21.0
walk up and cottage	2	108	42.9	42.9	63.9
House	3	91	36.1	36.1	100.0
	Total	252	100.0	100.0	

Valid cases 252 Missing cases 0

LOCATION by CLASS1 collapsed class

CLASS1 Page 1 of 1

LOCATION	Count	High rise flat 1	walk up and cott 2	House 3	Row Total
M8 / M9	1	45	59	42	146 57.9
M22 / M23	3	8	49	49	106 42.1
	Column Total	53 21.0	108 42.9	91 36.1	252 100.0

Number of Missing Observations: 0

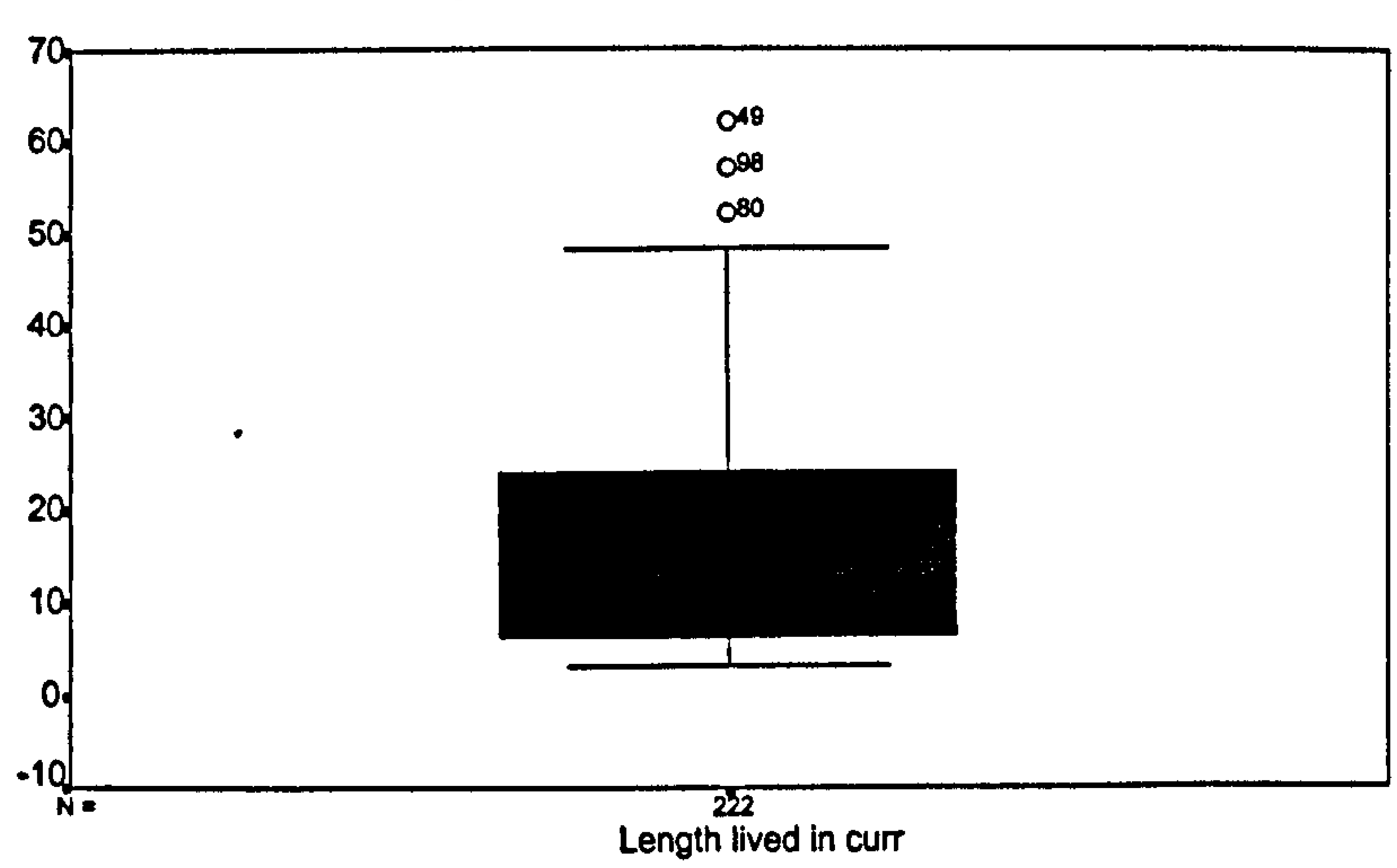
APPENDIX 3.7

Exploratory data displays of stem-and-leaf and boxplots for selected variables.

LENTLIVE Length lived in current house

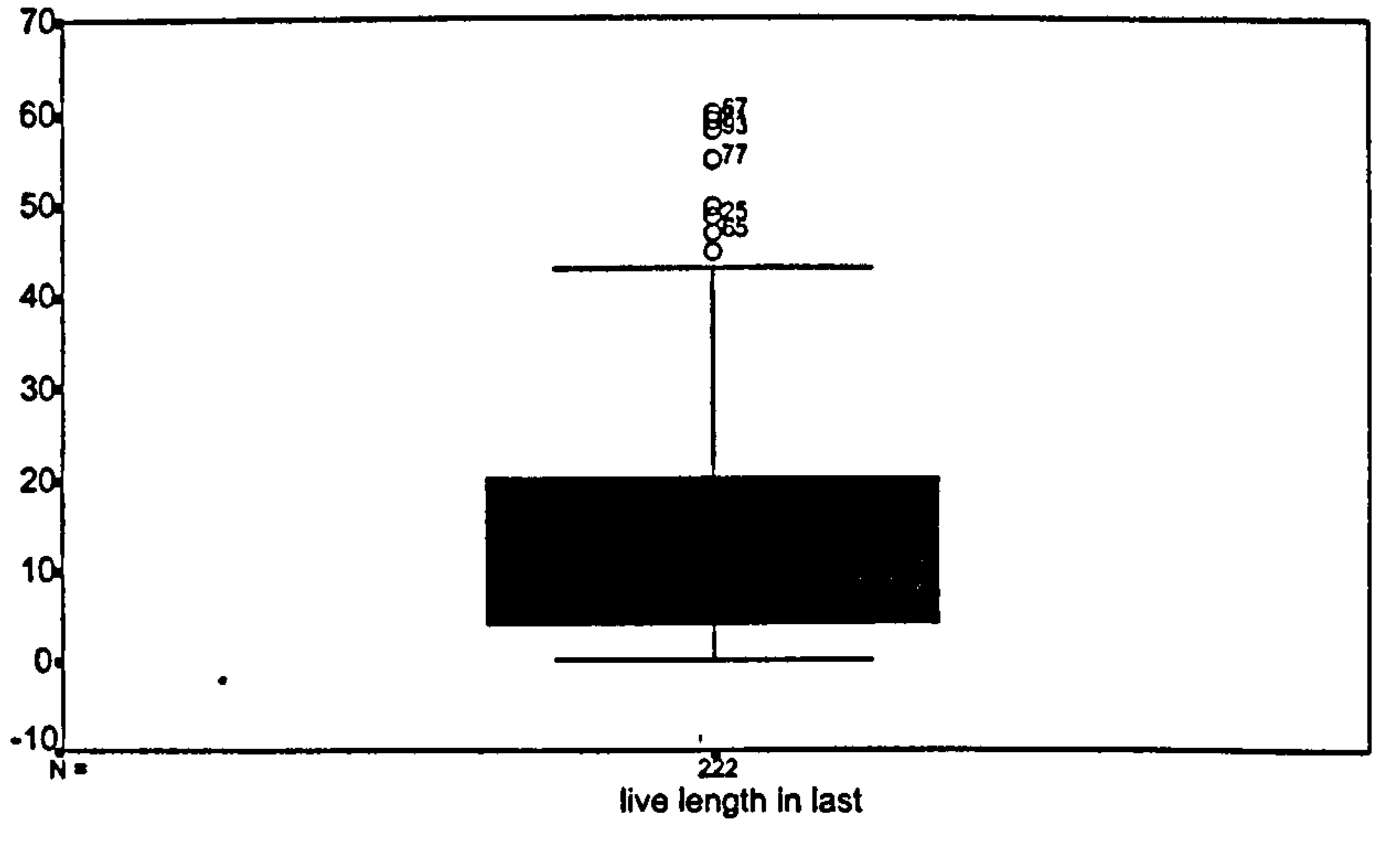
```
 Valid cases:        222.0   Missing cases:       30.0   Percent missing:    11.9


 Mean        16.6824  Std Err       .8759  Min          3.0000  Skewness    1.0397
 Median      12.0000  Variance  170.3025  Max         62.0000  S E Skew     .1633
 5% Trim     15.6652  Std Dev    13.0500  Range       59.0000  Kurtosis     .3390
 95% CI for Mean (14.9563, 18.4085)       IQR         18.0000  S E Kurt     .3252


Frequency    Stem &  Leaf

   28.00        0 *  3333333334444
   66.00        0 .  555555555566666666777777788888999
   24.00        1 *  00011122234
   27.00        1 .  5556666788899
   25.00        2 *  00123333444
   10.00        2 .  667&
   17.00        3 *  0012224
    3.00        3 .  7&
   14.00        4 *  000023&
    5.00        4 .  78&
    3.00 Extremes    (52), (57), (62)

 Stem width:       10
 Each leaf:      2 case(s)


 & denotes fractional leaves.
```

Hi-Res Chart # 3:Boxplot of lentlive



```
LENTLAST  live length in last home

 Valid cases:        222.0   Missing cases:      30.0   Percent missing:    11.9


 Mean        14.1261  Std Err      .9135  Min          .0000  Skewness    1.3770
 Median      10.0000  Variance  185.2510  Max        60.0000  S E Skew     .1633
 5% Trim     12.7848  Std Dev    13.6107  Range      60.0000  Kurtosis    1.3375
 95% CI for Mean (12.3259, 15.9264)       IQR        16.0000  S E Kurt     .3252


 Frequency    Stem &  Leaf

    64.00        0 *  01111112222222233333333444444
    45.00        0 .  5555555666666667788889
    32.00        1 *  0000000011222344
    16.00        1 .  555778&
    23.00        2 *  0000023333&
     8.00        2 .  557&
    13.00        3 *  00024&
     3.00        3 .  5
     5.00        4 *  0&
    13.00 Extremes    (45), (47), (49), (50), (55), (58), (59), (60)

 Stem width:        10
 Each leaf:       2 case(s)


 & denotes fractional leaves.
```

Hi-Res Chart   # 4:Boxplot of lentlast



PROPAGE age of property

Valid cases: 222.0 Missing cases: 30.0 Percent missing: 11.9

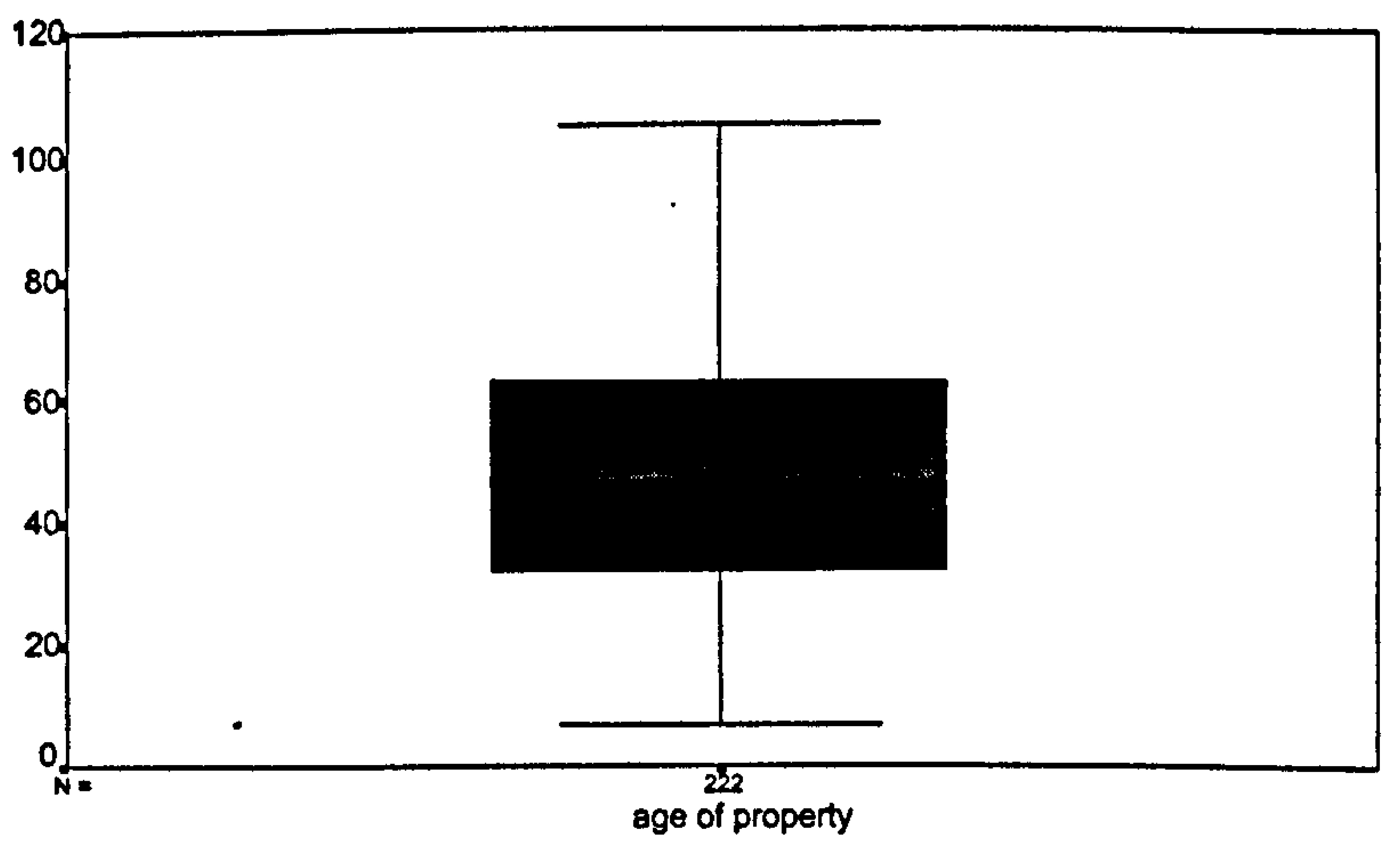
Mean	47.9775	Std Err	1.3081	Min	7.0000	Skewness	-.0698
Median	46.0000	Variance	379.8592	Max	105.0000	S E Skew	.1633
5% Trim	48.1852	Std Dev	19.4900	Range	98.0000	Kurtosis	-1.0174
95% CI for Mean	(45.3996, 50.5554)			IQR	31.0000	S E Kurt	.3252

Frequency	Stem &	Leaf
4.00	0 .	77
6.00	1 .	7&
43.00	2 .	00344444444444455666&
18.00	3 .	2222333&
50.00	4 .	0001111122222233335667777
16.00	5 .	7777999
41.00	6 .	012333333333333377&
43.00	7 .	1111111111116666666&
.00	8 .	
.00	9 .	
1.00	10 .	&

Stem width: 10
Each leaf: 2 case(s)

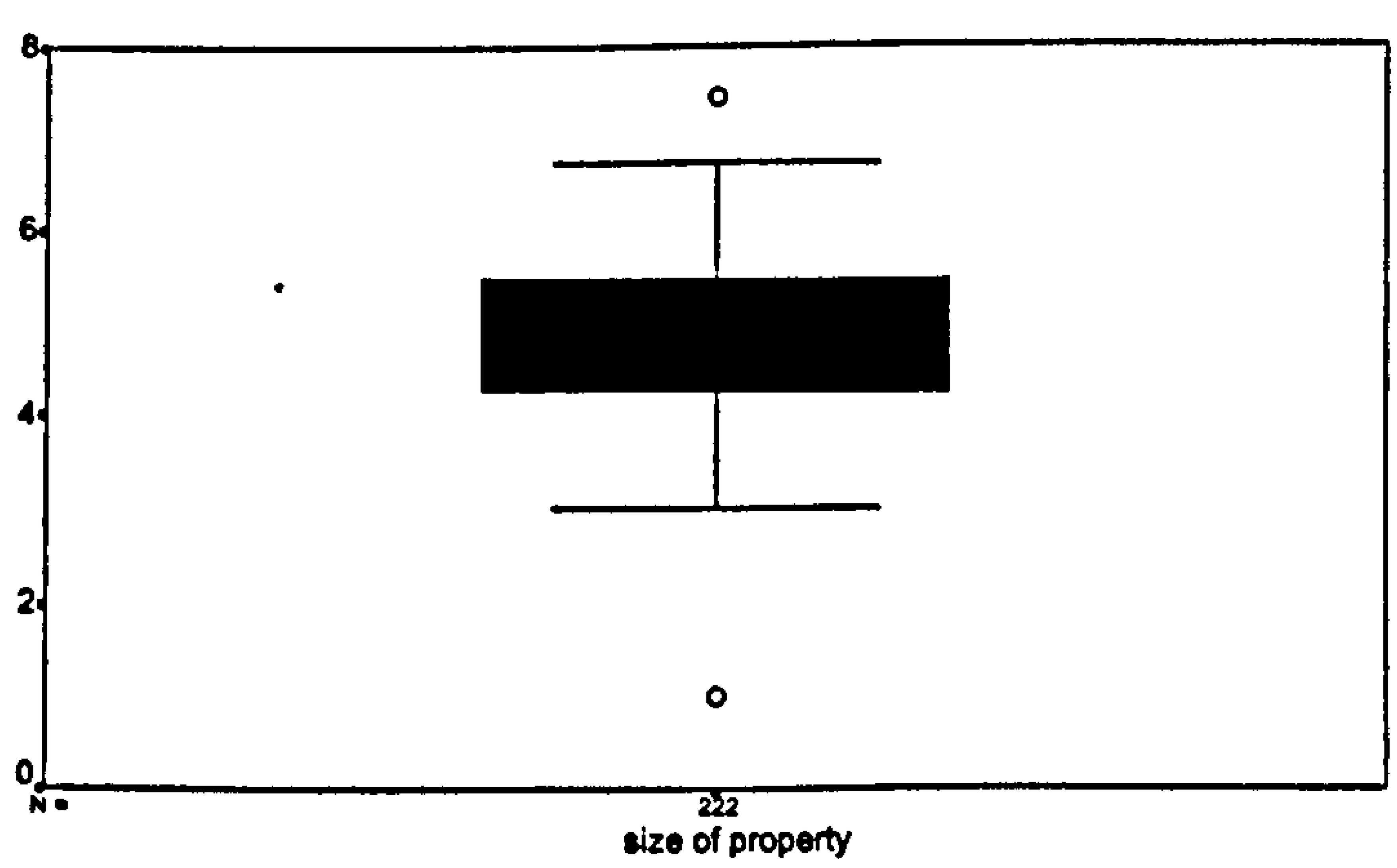
& denotes fractional leaves.

Hi-Res Chart # 5:Boxplot of propage



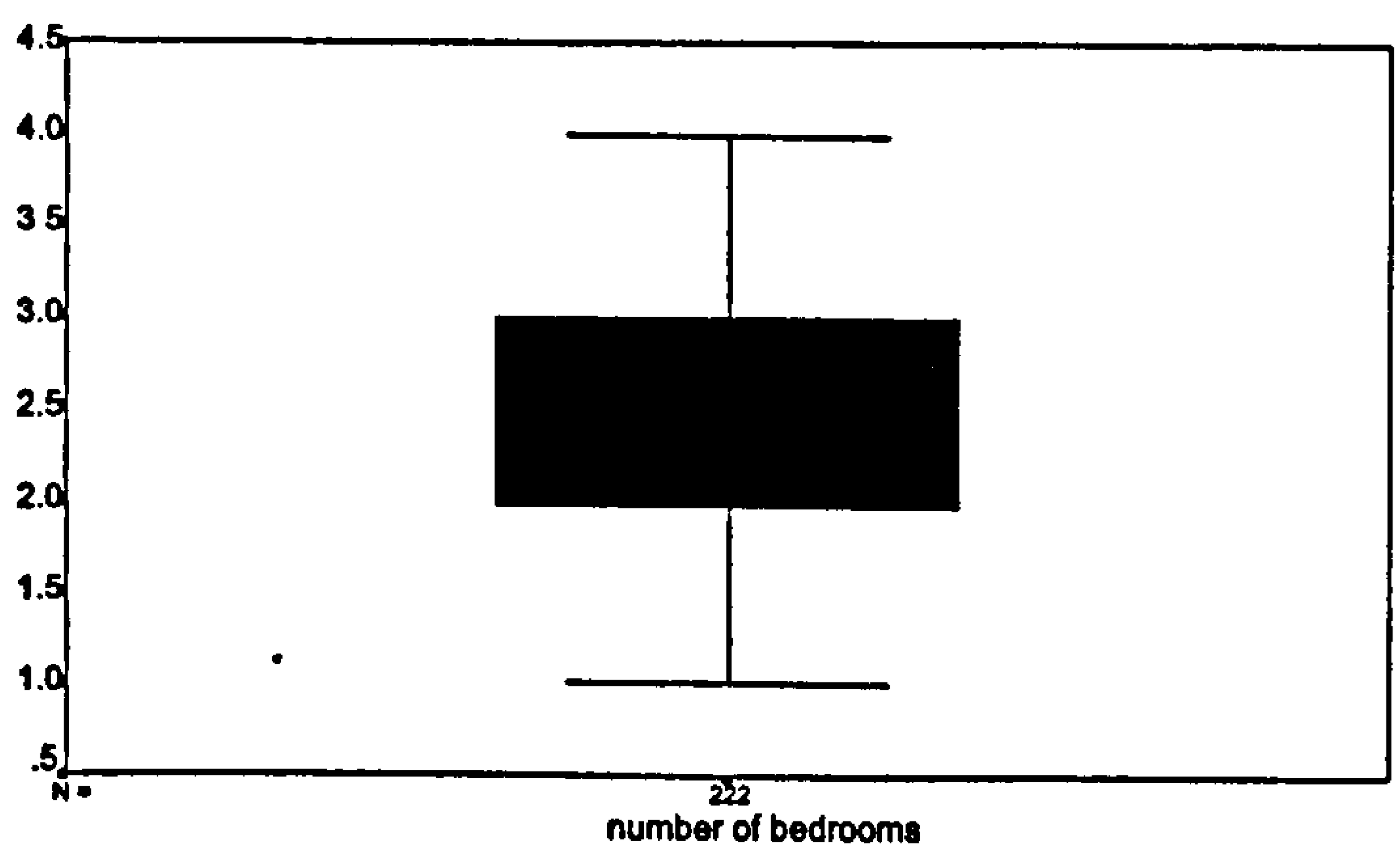
```
SIZE      size of property

Valid cases:       222.0   Missing cases:      30.0   Percent missing:    11.9


Mean        4.5777  Std Err      .0653  Min         1.0000  Skewness     -.0697
Median      4.3750  Variance     .9473  Max         7.5000  S E Skew      .1633
5% Trim     4.5577  Std Dev      .9733  Range       6.5000  Kurtosis     1.0218
95% CI for Mean (4.4490, 4.7064)        IQR         1.2500  S E Kurt      .3252


Frequency    Stem &  Leaf

    2.00 Extremes    (1.0)
    2.00        3 *  0
   35.00        3 t  22222222222222222
    1.00        3 f  &
     .00        3 s
     .00        3 .
    1.00        4 *  &
   70.00        4 t  22222222222222222222222222222222222
   34.00        4 f  55555555555555555
     .00        4 s
     .00        4 .
    1.00        5 *  &
     .00        5 t
   65.00        5 f  55555555555555555555555555555555
     .00        5 s
     .00        5 .
     .00        6 *
     .00        6 t
    7.00        6 f  555
    2.00        6 s  7
    2.00 Extremes    (7.5)

Stem width:       1.00
Each leaf:        2 case(s)


& denotes fractional leaves.
```

Hi-Res Chart # 6:Boxplot of size



```
    BED        number of bedrooms

Valid cases:        222.0   Missing cases:       30.0   Percent missing:    11.9


Mean          2.1757  Std Err       .0487  Min          1.0000  Skewness     -.1368
Median        2.0000  Variance      .5256  Max          4.0000  S E Skew      .1633
5% Trim       2.1852  Std Dev       .7250  Range        3.0000  Kurtosis     -.7973
95% CI for Mean (2.0798, 2.2716)           IQR          1.0000  S E Kurt      .3252


Frequency    Stem &  Leaf

   40.00        1 *  0000000000000
     .00        1 t
     .00        1 f
     .00        1 s
     .00        1 .
  105.00        2 *  00000000000000000000000000000000000
     .00        2 t
     .00        2 f
     .00        2 s
     .00        2 .
   75.00        3 *  0000000000000000000000000
     .00        3 t
     .00        3 f
     .00        3 s
     .00        3 .
    2.00        4 *  0

Stem width:          1
Each leaf:         3 case(s)
```

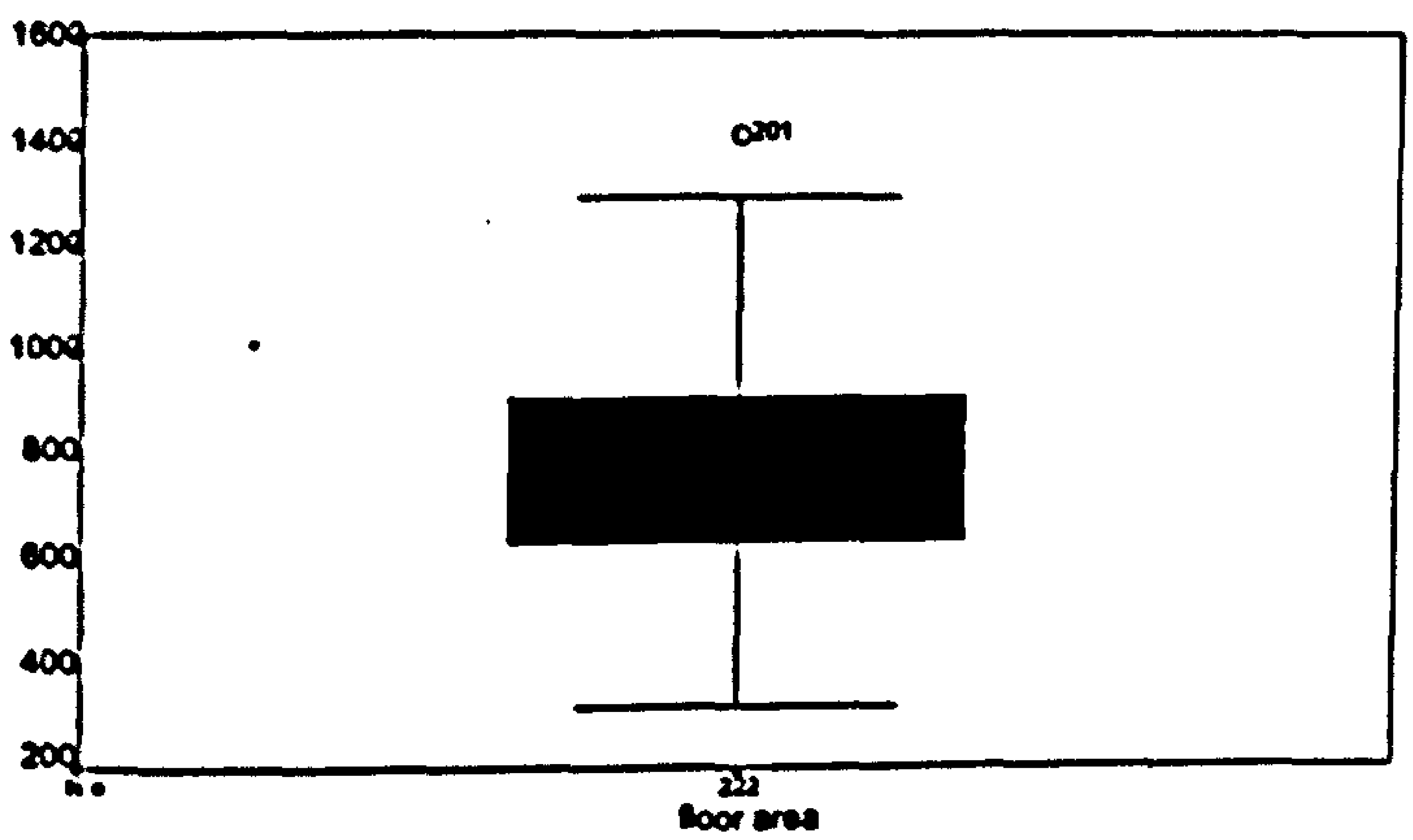
Hi-Res Chart # 7:Boxplot of bed



FLAREA floor area

```
Valid cases:       222.0   Missing cases:      30.0   Percent missing:    11.9


Mean       766.1892  Std Err     13.8464  Min        319.0000  Skewness      .4035
Median     711.0000  Variance  42562.52   Max       1411.000   S E Skew      .1633
5% Trim    760.2187  Std Dev    206.3068  Range     1092.000   Kurtosis     -.2854
95% CI for Mean (738.9013, 793.4771)      IQR        280.0000  S E Kurt      .3252


Frequency    Stem &  Leaf

    3.00        3 *  113
    1.00        3 .  7
     .00        4 *
    8.00        4 .  67888888
   27.00        5 *  000011111111111111112222333
    5.00        5 .  55889
   18.00        6 *  111122222222222233
   45.00        6 .  555555555556666667777777777788888999999999999999
   15.00        7 *  011111111111112
    7.00        7 .  5555558
    6.00        8 *  111114
   18.00        8 .  555899999999999999
   27.00        9 *  000000000000000011111122222
   13.00        9 .  5555555555799
    4.00       10 *  4444
   14.00       10 .  66777778899999
    4.00       11 *  0033
     .00       11 .
    4.00       12 *  2222
    2.00       12 .  89
    1.00 Extremes    (1411)

Stem width:       100
Each leaf:        1 case(s)
```

Hi-Res Chart # 8:Boxplot of flarea



VANDAL VANDALISM INDEX

Valid cases: 222.0 Missing cases: 30.0 Percent missing: 11.9

Mean	15.0172	Std Err	.2745	Min	6.0000	Skewness	-.3339
Median	15.4356	Variance	16.7291	Max	24.0000	S E Skew	.1633
5% Trim	15.0776	Std Dev	4.0901	Range	18.0000	Kurtosis	-.0391
95% CI for Mean (14.4762, 15.5582)				IQR	4.6478	S E Kurt	.3252

Frequency	Stem &	Leaf
11.00	Extremes	(6.0)
4.00	7 .	0088
4.00	8 .	0000
9.00	9 .	000000889
10.00	10 .	0000001259
7.00	11 .	0000056
10.00	12 .	0000001689
10.00	13 .	0011155799
19.00	14 .	0000000000000115577
36.00	15 .	000000000000000000000111123555556889
35.00	16 .	00000000000000000111155555555556678
17.00	17 .	00000001226666688
15.00	18 .	000000000111467
12.00	19 .	000000011455
7.00	20 .	0000099
2.00	21 .	00
7.00	22 .	0000011
4.00	23 .	0000
3.00	24 .	000

Stem width: 1
Each leaf: 1 case(s)

Hi-Res Chart # 9:Boxplot of vandal