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Sustainable Construction: Analysis of Its Costs and Benefits

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Abstract Sustainability has become the most important issue concerning the construction industry in the 21st century. The objectives of this paper were: to establish if there is an opinion within the industry that sustainability means increased cost; and to investigate whether using sustainable construction methods save money by reducing a buildings carbon output and running costs. Following the literature survey, a questionnaire survey has been carried out to canvas opinions within the industry. Furthermore, comparison of a traditionally built structure (the original college) against a sustainably built one (the structure being built to replace the original building) has been carried out as a case study with respect to the running costs and carbon outputs. The findings revealed that there is an opinion within the industry that sustainability means increased cost and complicated build ability and that using sustainable construction methods save money by reducing a buildings carbon output and running costs. This paper will benefit clients and developers as they can see how incorporating sustainability into new buildings will enable big savings on utility and maintenance costs once the building is operational.

Keywords: sustainable construction, benefits of sustainable construction, cost of sustainable construction

1. Introduction

The construction industry is a significant contributor to the UK economy. Its output is over £100 billion a year and it accounts for 8% of the UK's Gross Domestic Product providing employment for around 3 million workers in the UK [1]. However, buildings are responsible for nearly half of the countries carbon emissions, half of the nation's water consumption and account for around one third of all waste sent to landfill [1]. Over the past 20 years the construction industry has come under a great deal of criticism as there has been a growing understanding that the current model of development is not sustainable. As a result of this, there has been a massive drive towards promoting sustainable construction.

The government has set out a vision to drive towards a sustainable construction industry. The report *"Strategy for* Sustain*able Construction"* [1] illustrates how serious the government is taking the promotion of a sustainable construction industry. The report signifies the UK government's aim to lead the world in sustainable construction. The "Strategy for Sustainable Construction" report represents a joint commitment from the government and the construction industry to work towards a more sustainable construction industry. Its core aims are: to reduce the construction industry's carbon footprint and consumption of natural resources; and to create a safer and stronger industry by training and retaining a skilled and committed workforce. It highlights specific actions taken by industry and government to achieve the targets covered by the UK government's sustainability agenda. Its vision is to structure and regulate businesses, to ensure that buildings and infrastructure are delivered in a more resource efficient and sustainable manner. With increasing energy and waste costs, tougher environmental legislation increased stakeholder expectations, major organisations within the industry are increasingly focussing their efforts on improving construction practices to enhance performance and demonstrate responsible behaviour. It is important that contractors harness the benefits of acting in a sustainable manner in order to become more efficient organisations and take advantage of the financial benefits, as well as having a more positive impact on the environment and society in general. Whilst there is a massive amount of literature available on sustainable construction, there is a limited amount of the research on the effect sustainable construction has on capital costs e.g.: [2] and [3]. For these reasons, the objectives of this paper are: to establish if there is an opinion within the industry that sustainability means increased cost; and to investigate whether using sustainable construction methods save money by reducing a buildings carbon output and running costs.

2. Literature Review

In 1992 the United Nations Framework Convention on Climate Change (UNFCCC) [4,5] acknowledged that the change in the earth's climate and its adverse effects are a common concern of mankind. As a result of this global convention, a treaty was formed to tackle the issue of climate change. At the outset, the treaty did not enforce any mandatory limits on greenhouse gas (GHG) emissions for individual nations, therefore making the treaty legally non-binding. However, the treaty allowed provisions for updates called 'protocols'. The most significant update to the treaty to date is the Kyoto Protocol which sets binding targets for reducing GHG emissions to an average of 5% against 1990 levels over the five-year period 2008-2012. The Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities" [4,5]. In 2007, a draft Climate Change Bill was published. The Bill aims to put in place a framework to achieve a mandatory 60% cut in the UK's CO_2 emissions by 2050 (compared to 1990 levels). In 2008, the Climate Change Act became law setting up a target of 80% reduction over 1990 [6]. The UK is the first country to set up such a long-range and significant carbon reduction target into law [7]

With the construction industry being one of the UK's leading industries [1], it was vital that the Government targeted the construction sector to ensure the maximum effect in terms of reducing carbon emissions and becoming more sustainable. The government has produced "The Strategy for Sustainable Construction" having two fundamental objectives, namely: to provide industry with a single, easily understood document that covering all main government policies and initiatives in the field of Sustainable Construction; and to stimulate organisations within the industry to uphold the ideology of sustainable construction and become proactive by setting their own targets, rather than merely complying with government legislation. In order for the vision for a sustainable construction industry to be fulfilled, the organisations operating within it need to be prepared to adhere to the vision. To achieve this, the UK Government created the "Sustainable Construction Task Group" tasked with identifying specific and cost-effective improvements in the quality and environmental performance of buildings, together with further actions that Government could take to facilitate faster progress. To ensure that the UK reaches its targets for emission reductions, the Government has introduced its own energy policy which outlines strategies in relation to carbon savings and usage of renewable energy sources. This legislation has since helped devise changes to existing building regulations such as those in "Part L–Conservation of Fuel and Power" and has advocated the need for assessment of building performances under Building Research Establishment (BRE)'s Environmental assessment methods. The UK government understands that it must take a lead role if sustainable development is to be successful and the targets set regarding sustainability are met. To further promote sustainable construction the government produced the report *"Sustainable Procurement and Operations on the Government estate"* designed to enforce sustainable procurement. Due to the fact that around 40% of the construction industry output stems from the public sector [8,9], it is important that the government promotes and enforces sustainable construction.

The UK construction industry is governed by a massive amount of legislation. The Building Act 1984 [10] is the enabling act under which the Building Regulations have been made. As a result of the government's aim of cutting down GHG emissions in line with the Kyoto Protocol and in general, with "Part L Regulations: Conservation of fuel and power" were introduced in 2001. As a result of these regulations, Architects and Engineers were tasked with designing and engineering more sustainable structures. Furthermore, Quantity Surveyors have found themselves looking for cost effective solutions to meeting the CO_2 targets set out in Part L. Part L regulations make contractors take reasonable measures to reduce heat loss through the building fabric and to improve the efficiency of services to the structure, such as mechanical ventilation, heating and lighting. Under Part L regulations, maximum CO_2 emissions have been set for buildings. The regulations apply to construction of all new buildings, and the refurbishment of existing buildings with a useable floor area of over $1000m^2$. For new buildings, it is forecasted that Part L will cut carbon emissions by 25% from 2002 standards, which had already cut emissions by 15%. The net reduction of 40% from pre 2002 is often used as a benchmark of progress [11]. Part L regulations are split into Part L1 and Part L2. Part L1 is concerned with domestic buildings, whereas Part L2 is concerned with non domestic buildings. Whilst the regulations obviously differ depending on the section in question, the principles are the same. Part L regulations are designed to make buildings more efficient and reduce carbon emissions. Examples of measures include: new performance standards for avoiding solar overheating; improving boiler efficiency, certain types of light fittings, display lighting systems; improving buildings that are air-conditioned or mechanically ventilated and the installation of energy consumption meters and sub-meters. Under Part L, energy performance of a building must be checked at the inception stage to ensure that it complies with the regulations and then be carefully monitored throughout its design and construction phases to make sure that it complies upon completion.

BREEAM (Building Research Environmental Assessment Method) was launched in 1990 [12]. Since its inception, BREEAM has become widely accepted as the benchmark for measuring environmental performance of buildings, becoming formally adopted by the UK Government. BREEAM provides guidance on how to minimize adverse effects of buildings on the environment, locally and globally by reducing energy usage in the construction and management of a building whilst encouraging a healthy and comfortable environment for end users. BREEAM's success stems from its unique ability to cover a wide range of environmental issues within one assessment, and to present the results in a way that is widely understood by those involved in property procurement and management [12,13].

Challenges to Sustainable Construction: Since the inaugural international conference on sustainable construction, in Tampa, USA in 1994, sustainable or "green" building has become a significant global issue [14]. A large number of pioneering projects have proved that green buildings can provide a far more comfortable, healthy, living and working environment for their end users, as well as having greatly reduced utility and

maintenance costs due to increased efficiency. The primary barriers to implementation, are the misconceptions that by adopting a more sustainable design and construction, higher capital costs will be incurred, without a worthwhile benefit to market value [3]. It is critical, therefore, to evaluate the capital costs of sustainable building, against those of traditional buildings and prove their worth, in order to motivate stakeholders to consider and use methods of sustainable construction. Furthermore, it is important to compare the carbon output of traditional buildings against those built with sustainable features, to highlight the increased efficiency and reduced carbon output and running costs. The UK construction industry is responsible for around half of the total CO_2 emissions, 90% of all surface mineral extraction and over a quarter of all waste sent to landfill [15]. Despite of these challenges, sustainable construction can be a strategic advantage for the contractors. [16]'s study revealed a positive relationship between sustainability performance and business competitiveness and highlighted that implementation of sustainable construction practice contributes to the improvement of contractors' competitiveness [16].

The Cost of Sustainable Construction: Sustainable Construction requires a long term view, considering initial capital cost, against running costs of the structure. The major economic benefits of sustainable construction are reduced operation and utility costs, reduced maintenance costs, and an overall improvement in the buildings performance and efficiency [14]. It is also perceived that the short term costs of sustainable practices are too high to justify their application in a highly competitive market. Despite of the substantial advances in best practice, there is a lag in the application of sustainable practices that improve building performance. This lag is mainly due to: the lack of client demand; and the belief that sustainable methods are more expensive than traditional construction methods. Cost consultants can add a significant margin of 10% to capital costs to allow for more sustainable solutions [3]. As stated by [2], the construction industry has long behaved in a secretive manner. Clients, contractors and stakeholders are generally reluctant about revealing information on costs. As a result, information on the costs of sustainable building has emerged slowly. It is increasingly being realized, that some requirements that were once assumed to increase costs, are actually proving to be cost neutral or better. One such example is sustainable urban drainage schemes, where clear savings are evident from the reduced costs of pipes and hard drainage [2]. [17] highlighted that there are a large number of economic benefits to constructing greener buildings and that the benefits include: energy cost savings; water cost savings; mechanical equipment downsizing. [18] stated that the business benefits of sustainable construction include: capital cost savings; reduced running costs; increased investment returns; increased productivity, staff recruitment and retention; more efficient resource use; major corporate image / marketing spin offs. [19], using two case studies, demonstrated that energy efficient designs could be achieved at a lower cost than conventional design. Achieving higher EcoHomes or BREEAM ratings can be achieved at little extra cost, and that a number of items are available at no additional cost or even a saving [3]. [20] have emphasised the need for a change in the feasibility studies. Their research revealed that the current practice of project feasibility study gives priority to the economic performance neglecting the social and environmental performances and [20] suggested the need for shifting the traditional approach of project feasibility study to a new approach that embraces the principles of sustainable development. Similarly, people should consider environmental and social sustainability of housing when they assess the housing affordability. [21]'s study emphasized this point and their study revealed that considering a range of social and environmental criteria can greatly affect the calculation of an areas affordability, in comparison to focusing solely on financial attributes.

3. RESEARCH METHODS

The objectives of this research were: to establish if there is an opinion within the industry that sustainability means increased cost; and to investigate whether using sustainable construction methods significantly reduces a buildings carbon output. With these objectives, the research methods consisted of: literature review; a questionnaire survey; and a case study.

- A closed multiple choice questionnaire has been applied to construction professionals. 40 questionnaires have been sent out to professionals within the industry. The questionnaires were kept anonymous in order to further increase the probability of a high response rate. Of the 40 questionnaires sent out, 24 were returned giving a response rate of 60%. In order to gain further qualitative insight into perceptions and opinions within the industry, the respondents were encouraged to make further open comments at the end of the questionnaire. The questionnaire and raw data are presented in the Appendix. As only 24 construction professionals answered the questionnaire, the findings can not be generalized for the whole construction industry. The findings, however, provide an insight on the tendency within construction industry.
- The case study consisted of comparison of a traditionally built structure against a sustainably built one. The original college has been compared against the structure being built to replace it. This comparison has been carried out with respect to the running costs and carbon outputs.

4. Results

4.1. Questionnaire Survey

(Q1) The majority of respondents are of the opinion that the majority of construction personnel are unaware of the fact that around 52% of the UK's CO_2 emissions are created by the construction and usage of buildings. Only a minority were of the opinion that many people are aware of the environmental impact of the industry in terms of its carbon footprint.

(Q2) Majority of respondents were of the opinion that sustainable construction methods result in increased capital costs. Only 1 respondent was of the opinion that sustainable construction could be achieved without increased capital costs.

(Q3) Most of the respondents were of the opinion that sustainable construction is important enough to warrant paying increased capital costs. However, 4 respondents stated that thought that if un-sustainable methods could be used to do the same job for a cheaper price they should be used. Furthermore, two respondents were unsure of what should be done in this scenario.

(Q4) Most of the respondents were of the belief that sustainable construction methods are as buildable as traditional methods. However, as with Q3, there was sizeable minority (5 respondents) who thought sustainable methods compromise ease of construction and two respondents were not sure.

(Q5) Majority of the respondents feel that regulations relating to sustainability, such as part L, have had a big effect on the industry. Of the 24 responses, 15 were of the opinion that government regulations have had a big effect. However, there were a number of respondents who thought government regulations have not had a big effect. 5 were of the belief that figures on energy usage, CO_2 emissions etc. can be manipulated simply to pass regulations and this may account for these responses. One of the respondents was unsure of their effect.

(Q6) Three respondents believe there is much awareness of government incentive schemes on sustainability. Majority of the respondents were of the opinion that there is little awareness of such incentives.

(Q7) Most of the respondents were of the opinion that designers are paying more attention to products used in the construction process. Only three respondents were of the opinion that this was not the case, and with two unsure respondents.

(Q8) Most of the respondents were of the opinion that the drive towards sustainable construction is having a positive effect on the industry and suggests that the workforce in general is supportive of sustainability. However, there were a minority of respondents who did not think it was having a positive effect and smaller minority was not sure.

(Q9) The majority of the respondents feel that enough is being done in terms of law and legislation to enforce a sustainable construction industry

(Q10) Additional comments of respondents are as follows:

"Obviously sustainability inflates overall building costs due to the new technology and products that are required to meet the criteria required. However, design teams and contractors should play a lead role in educating clients (public and private) in the reduction of CO_2 generated by sustainability and how in the long run, sustainability issues reduce the Life Cycle costs of building in terms of maintenance*, heating and running costs."*

"I believe a number of companies are trying to lead the way. However enhanced education and communication are needed to ensure compliance by all parties. Government needs to be strong in its legislation to enable all parties to adhere to the same rules. More work needs to be done by manufacturers to ensure 'green' products *are commercially viable."*

"The knowledge of funding for sustainability has more awareness within the industry where public funding is *used."*

*"The cost of su*stainability needs to come down. As the governments target to make schools zero carbon by 2016 approaches, it is hoped that the current underdeveloped market of renewable will become more developed and in turn bring down the cost of sustainability through greater *competition between suppliers and subcontractors."*

"I believe that the public sector construction industry is striving to achieving sustainable developments, however from what I have seen of the private sector there seems to be very little put forward to enhance sustainable construction. It always seems to be a token gesture which ticks the boxes for regulations but does not really go any further than this. The building regulation change in 2006 has helped with starting designers to think about energy conservation and efficient building design, however it is very easy to make a building design work and pass building regulations but still be an in-efficient building if *you know how the calculations are put together."*

"Sustainable construction tends to cost more, but it does not have to. If the building is designed well at the start of the job (taking account of orientation etc), then a sustainable solution can be delivered at a more *reasonable cost."*

4.2. Case Study

The original college was built in the 1940's, of cavity brick construction, and was added to in the 1990's with further cavity brickwork structures. It is a secondary school for 1200 children aged 11-16 years old. It has a gross useable floor area of 12,828m^2. The school's main heating fuel is natural gas through a one way flow radiator system. The building is naturally ventilated. The buildings electricity usage comes off the national grid and there are no energy management systems in place for electricity and lighting. Everything is turned off or on manually. The internal ceiling heights are on average around 3 meters high from finished floor level. The roof is a pitched roof with 100mm of insulation. The windows are metal framed with double glazing. The building has no on site renewable energy sources.

A report was carried out on 25/11/08 to examine the buildings energy efficiency under *"The Energy* Performance of Buildings (Certificates of Inspections) *(England and Wales) Regulations 2007".* The report showed that the building was highly inefficient, achieving a "G" rating, the worst possible. A number of options to improve the efficiency were detailed in the report. These options included introducing energy management techniques and improvement of the loft insulation. However, these options have been ignored as under the Government's BSF (Building Schools for the Future) scheme the school was due to be replaced by a new secondary school. From the information made available by St Helens Council, the buildings CO_2 emissions per m^2 is presented in the Table 1.

Table 1. The original college's CO_2 emissions per m^2

Total CO_2 Emissions (Electricity + Fossil Fuel)	College's Gross Useable Floor Area (m^2)	CO_2 emissions per m^2 (Total CO_2 Emissions / Gross Useable Floor Area)(kg/m^2)
633,129	12,828	49

Whereas the original college was built in an era long before the Kyoto Protocol, the new college is being constructed in an era where sustainability is a primary concern in the public sector. The building is being

constructed to conserve energy over its life span and limit its CO_2 emissions. The following are a number of the sustainable features in place on the building:

- Thick Insulated Walls - The walls are made up of Structural Insulated Panels which are factory engineered and brought to site for erection with almost zero waste. The panels are sealed together so that the joints do not leak preventing air and heat loss.
- Mechanically Operated Windows – When the classrooms get too hot or there is a build-up of CO_2 the windows will automatically open allowing fresh air in. Air vents on the back walls of each classroom allow air to circulate from the rooms into the corridor and out through windows at the top of the corridor atria. Having this natural ventilation means everybody gets the right amount of fresh air without the need for air conditioning.

Spacious Classrooms – High ceilings of the classrooms enable the large windows to let in natural light reducing the need for lighting.

- Low energy computer systems – Low energy computer systems reduce electrical consumption and heat output.
- Solar Panels – Solar panels are situated on the roof and will provide 70% of all hot water demand for washing hands, etc.
- Highly Efficient Lighting – The building has dimmable daylight controls and occupancy control sensors.
- Recycled Rainwater – Rainwater from the roof is used to flush the toilets. Special tarmac in the car park allows water to soak through it into the ground avoiding unnecessary water entering the sewers.
- Biomass Boiler – Biomass boiler uses wood chips to provide hot water for the under floor heating and it is carbon neutral.

Using a calculation called SBEM (Simplified Building Engineering Model); a building's energy use and CO_2 emissions can be accurately predicted. SBEM computer program provides an analysis of a building's energy consumption [22]. SBEM calculates monthly energy use and CO_2 emissions of a building given a description of the building geometry, construction, use and HVAC (Heating Ventilating and Air Conditioning) and lighting equipment [22]. An SBEM analysis was done by Gill Massey Consulting Engineers on the new college, taking into account all aspects of the building such as the U-Values of the external envelope and the heating and lighting systems. The results showed that the predicted carbon output per m^2 of useable floor area will be 14.55kg/m^2, as presented in Table 2.

Table 2. The new college's CO_2 emissions per m^2

Total CO_2 Emissions (Electricity + Fossil Fuel)	New college's Gross Useable Floor Area (m^2)	CO_2 Emissions Per m^2 (Total CO_2 Emissions / Gross Useable Floor Area) (kg/m^2)
130,543	8,972	14.55

Table 2 shows that the new college will omit 34.45kg/m^2 of carbon per annum less than the original college. If this is calculated over the next 25 years, it is seen that new sustainable building methods used to build the new school will save 861.25kg/m^2 of CO_2 as seen in Figure 1. This highlights how modern building methods have vastly increased the efficiency of buildings and in turn reduced CO_2 emissions.

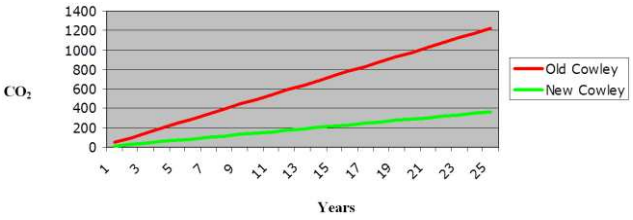

Figure 1. Carbon emission comparison of old and new college

There are incentive schemes available to contractors operating in the public sector to gain extra funding by hitting certain targets on sustainability. One such scheme offers extra funding of £50.00 per m^2 of useable floor area if a 60% reduction on 2001 baseline emissions is achieved on a typical secondary school. A typical secondary school built in 2001 would on average emit 36.80kg/m^2 of CO_2 per annum. A school built to comply with 2006 Part L regulations would have to emit no more than 30.50kg/m^2 of CO_2 per annum. If a secondary school built now can achieve a 60% reduction on the baseline figure set in 2001 (14.756kg/m^2 per annum), then the government offers extra funding of £50.00 per m^2 of useable floor area as an incentive. As the new Cowley will emit 14.55kg/m^2 CO_2 per annum; which is less than the 60% reduction figure of 14.756kg/m^2 CO_2 per annum, as a result it qualifies for this incentive and receives the extra funding.

It is estimated that incorporation of all sustainability features in the new college has come at a cost of £35.21 per m^2 (SBEM analysis and department for schools children and families carbon calculator tool). The extra funding is £50.00 per m^2, so there is benefit of £14.71 per m^2 gained by achieving the target set by the government. This equates to a clear benefit of £132,681.10 when multiplied out by the 8,972m^2 of useable floor area on the school. This highlights how by hitting government targets, clients and contractors can build more sustainable buildings without having to pay the increased capital costs and that they can actually make a greater profit by qualifying for benefits offered by the government.

5. Discussion

The questionnaire survey highlighted the tendency within the industry to perceive that sustainable construction methods cost more than traditional methods. However, there is a common belief that sustainability is important and that the problem of increased cost must be addressed. As majority of respondents are unaware of the fact that around most of the UK's CO_2 emissions are created by the construction and usage of buildings, more needs to be done to educate employees of the construction industry on the environmental impacts of the industry. Majority of respondents were of the opinion that: sustainable construction methods result in increased capital costs supporting [3] and [18]; and that sustainable construction methods are as buildable as traditional methods. Most of the respondents were of the opinion that regulations relating to sustainability have had a big effect on the industry. Majority of the respondents highlighted that: there is little awareness of government incentive

schemes on sustainability; designers are paying more attention to products used in the construction process; private sector clients are not concerned by sustainability to the same extent as public sector clients; the drive towards sustainable construction is having a positive effect on the industry; enough is being done in terms of law and legislation to enforce a sustainable construction industry. The questionnaire survey findings revealed that:

- the perception of high capital costs emerging due to sustainable construction can obstacle widespread
- the government needs to do more to market incentive schemes across the construction industry in order to increase the awareness of the parties.
- the government is doing its part in driving sustainable construction in terms of law and legislation to enforce a sustainable construction industry and that it is up to the contractors operating in the sector to operate in a sustainable manner.
- as designers are perceived to paying more attention to products used in the construction process, the drive towards sustainability is having an effect on the construction and the environmental impacts and life cycles of materials used are considered more due to the sustainable construction ethos.
- following points should be paid attention to enhance sustainable construction: stricter government legislation, enhanced education and communication to ensure compliance by all parties; greater care at design stage to deliver sustainable solution at a more reasonable cost; more competition between manufacturers to reduce cost associated with sustainability; and need for more work to make sustainable practice become common practice.

The case study compared the original college with the new college. The findings revealed that the new building is expected to omit 34.45kg/m^2 of carbon per annum less than the original college. The new school is expected to save 861.25kg/m^2 of CO_2 over the next 25 years. This highlights how modern building methods can increase the efficiency of buildings and reduce CO_2 emissions. Furthermore, the new college is expected to qualify for the incentive and receives the extra funding of £50.00 per m^2 of useable floor area as an incentive. This reveals that the capital costs of sustainable buildings can decrease by hitting government targets. In this way, clients and contractors can build more sustainable buildings without having to pay high capital costs and they can benefit the extra funding by qualifying for the incentive. The case study revealed economic benefits of sustainable construction and supported: [2,14,17,18,19].

6. Conclusions and Recommendations

The objectives of this paper were: to establish if there is an opinion within the industry that sustainability means increased cost; and to investigate whether using sustainable construction methods save money by reducing a buildings carbon output and running costs. With these objectives the research methods consisted of: the literature review; questionnaire survey; and a case study which compared the original college against the structure being built to replace it with respect to the running costs and carbon outputs.

The questionnaire survey results suggest that the majority of the respondents is of the opinion that sustainability does generally mean increased capital costs. However, the results also showed that most respondents were of the opinion that sustainable construction techniques should be used even if the capital costs are greater. The onus is on the suppliers and contractors within the market to drive the costs of sustainable construction through competition and more economic production. On the other hand, there are many measures that can be taken to make a building more sustainable without inflating capital costs, for example, taking into account building orientation to maximise the natural light and energy captured. Case study revealed that sustainable methods are effective and produce far more efficient buildings. The new building is expected to be more carbon output efficient than the older one. Moreover, the case study highlighted that by hitting a government target on CO_2 output, £50 per m^2 of useable floor space can be gained in extra funding. This showed how increased capital costs incurred for producing a more sustainable building can be recouped. However, questionnaire survey results showed that most of the respondents are of the opinion that there is little awareness of such schemes. This can hinder widely adoption of sustainable construction across the industry.

In conclusion, this study highlighted the tendency that: there is an opinion within the industry that sustainability means increased cost; using sustainable construction methods save money by reducing a buildings carbon output and running costs; construction personnel recognise the importance of sustainable construction and support its implementation even if capital costs are greater; sustainable construction can make a huge impact in terms of reducing buildings carbon output and running costs. Therefore more should be done, particularly at industry level to ensure all new buildings are built with sustainable construction methods.

Following recommendations have been identified to enhance sustainable construction:

- stricter government legislation, enhanced education and communication are needed to ensure compliance by all parties;
- greater care at design stage should be paid to deliver sustainable solution at a more reasonable cost;
- Competition between manufacturers should be increased to reduce cost associated with sustainability; and
- more work is needed to make sustainable practice become common practice.
- people's awareness on government incentives should be increased so that they can be motivated for more sustainable construction.

Limitation to this study is the low response rate to the questionnaire. For this reason, the findings can not be generalized for all construction professionals in the UK. The findings, however, provide an understanding of views and perceptions within the UK construction industry.

Further researches can be carried out on: the reasons why private sector clients are perceived not to be concerned with sustainability; and how much the leading organisations within the industry are doing to adhere to the government vision.

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Appendix: Questionnaire and Raw Data

1. Around 52% of the UK's CO_2 emissions are created by the construction and usage of buildings. Do you think that many personnel within the construction industry are aware of this fact?

[3] Yes; [20] No; [1] Not Sure

2. Sustainable construction methods can significantly reduce $C0_2$ emissions and wastage. Do you think the use of these methods generally results in increased capital costs?

[19] Yes; [1] No; [2] Not Sure; [2] Missing

3. In your opinion, should sustainable building methods be used even if the capital costs are greater?

[15] Yes; [4] No; [2] Not Sure; [3] Missing

4. In your opinion, with the focus on sustainability, is the ease of construction compromised?

[5] Yes; [14] No; [2] Not Sure; [3] Missing

5. The UK Government has set out a number of detailed regulations to enforce sustainable construction, for example Part L: Conservation of Fuel & Power. Do you think government regulations such as this have had a big effect on the industry?

[15] Yes; [5] No; [1] Not Sure; [3] Missing

6. The UK Government have a number of incentive schemes in place offering additional funding if certain sustainability targets are met. Do you think there is much awareness of this within the industry?

[3] Yes; [16] No; [2] Not Sure; [3] Missing

7. With the industry's drive towards sustainability, do you think designers generally are paying more attention to materials used in the construction process, to ensure the most efficient products are used?

[16] Yes; [3] No; [2] Not Sure; [3] Missing

8. Do you think the drive towards a more sustainable construction industry is having a positive effect on the industry as a whole?

[16] Yes; [3] No; [2] Not Sure; [3] Missing

9. Do you feel that enough is being done to enforce a more sustainable construction industry?

[19] Yes; [1] No; [2] Not Sure; [2] Missing

10. Do you have any additional comments?