

# Achieving sustainability in construction and maintenance of housing. An analysis based on a comparison of the Dutch and Peruvian situation

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## **ACHIEVING SUSTAINABILITY IN CONSTRUCTION AND MAINTENANCE OF HOUSING**

(An analysis based on a comparison of the Dutch and Peruvian situation)

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### **ABSTRACT**

Recently, the author worked as a development aid worker in Peru. Lessons are drawn from this experience and from experience in the Netherlands, comparing the differences in sustainable building caused by culture, history and available techniques. Exchange of technology or technology transfer may help countries to learn from each other and achieve more sustainability.

The paper uses examples drawn from the Netherlands and Peru of achieved and achievable sustainability with an eye to the functional quality, the architectural quality and the use of resources for housing. This is done for the building product, the system and the building as a whole. When comparing the situation in both countries, we find that Peru, as a LDC, sometimes has the advantage of being “retarded” in its development. Therefore, the correction of “negative” actions towards the environment can be made far more easily than in the case of a developed country. Transfer of technology (North-South & South-North) and choice of technology may be important.

Based on experiences in both countries, a research programme was set up. The paper describes the investigation into the reduction of waste and residues by carrying out sustainable renovation and maintenance projects.

### **KEYWORDS:**

Sustainability; housing; less developed countries; renovation; research.

### **INTRODUCTION**

The concept of sustainable construction and maintenance varies from country to country, caused by differences in culture, climate, techniques, politics and level of development. Making comparisons between countries can teach us many important lessons. This paper is a reflection on, and analysis of, experiences gained during a three-year stay at the IIUR (Instituto Investigación Universidad y Región) of the University of Cusco (UNSAAC) in Peru. As a technical expert attached to the university, I taught courses and did research on low-cost housing in relation to solving environmental problems (Erkelens, 1999a).

During this period I became more and more convinced that global solutions might be only partly valid, because solutions very much depend on the local situation. Think globally but act locally is therefore more appropriate. We can learn from experiences and examples in other countries and transfer of promising building technologies and approaches can speed up the achievement of targets set for durable construction and maintenance. But, this also has its constraints. The paper presents examples of sustainability in construction and maintenance.

Finally information is provided on follow-up research being carried out at the Technische Universiteit Eindhoven on the limitation of waste production and demolished products /materials, when maintaining and renovating buildings in a sustainable way.

## **THEORETICAL FRAMEWORK**

Comparing sustainable construction and maintenance between various countries will be based on the Dutch national environmental policy plans (NEPP). These policy plans for sustainable building contain important themes and policies for reducing environmental impact. The following concepts are developed:

1. Integrated Life Cycle Management –LCM- (= closing the loop)
2. Energy efficiency and conservation and
3. Quality improvement of products and processes (MVRM, p. 12).

These concepts can be considered valuable for all countries.

The following examples of ‘achieved’ and ‘achievable’ sustainability for building products, systems and buildings will be categorised into LCM & Energy aspects and Quality aspects.

## **EXAMPLES OF ACHIEVED & ACHIEVABLE SUSTAINABILITY**

In this section some examples of achieved and achievable sustainability of construction and maintenance are reviewed. This is done for the building product, the building system and the building in its totality, in the light of LCM & Energy aspects, emphasising resources and of Quality aspects, emphasising functional quality and architectural quality.

### **Life cycle & Energy aspects**

In an old city like Cusco in Peru, for example, 80% of the buildings are constructed with adobe (Erkelens, 2000b). This is a material that contributes significantly to sustainable building. It is recyclable - as are other materials - but this material really can “return” to its original state without any effort. For other materials it remains questionable whether they will be recycled in the future, because of changing policies. Those materials require human intervention for recycling.

Cusco and other cities show that it is indeed possible to use indigenous materials in a sustainable way. However, there are negative factors for houses being built with simple materials rather than “noble” ones (stone, bricks, concrete, etc.). The Materials Bank for example will not provide loans for such houses. Attitude is another negative factor. In a country like the Netherlands, indigenous materials can be used, but a change in market mentality is required to apply these materials. This may be influenced by incentives like green or ecological mortgages, or other forms of taxation, by positively discriminating for “eco materials”. There are also other positive developments; for example, the appearance of plato timber (local softwood, hardened through a specific cooking process). This timber is replacing tropical wood in the Netherlands.

In Peru, building materials, such as blocks, usually are available locally and are often produced on the construction site. This system is adequate for self-help construction.

Although Dutch building materials are produced in a factory, there are not many negative factors attached to indigenous materials. Here the applied building system can be simpler because of the absence of earthquakes. However, another phenomenon exists here: because of the rising shortage of water, it is necessary to design systems in such a way that buildings are more autarkic, through rainwater receptors, water storage, and water treatment for recycling, and photovoltaic roofing for the generation of electricity. There is a growing interest in this in the Netherlands.

Both in the Netherlands and in Peru, the education of architects is not geared towards making designs for low-cost housing, although it is far more difficult to make a design for this type of housing, with limited resources and possibilities than to make a design with unlimited resources. This is not felt as a challenge by many of the architects. As an example, we have been unable to find the ultimate Dutch

design for compact but spacious housing in the urban centres. Such a design could deter people from moving to rural areas, thus occupying areas needed for nature, etc., saving both your resources and energy.

### **Functional quality and Architectural quality**

The quality of architecture is important for making the building attractive to the user. In this context, the type of building materials and their characteristics are very important. The shape of the materials sometimes dictates the layout and design. The acceptance of certain building materials can be a problem at times in some countries. Adobe as a building material is considered to be a poor man's material, and therefore is often "upgraded" (replaced). The solution may be to design and optimise the specific materials' characteristics, so that people prefer the materials. Buildings for the government may be used as a showpiece to demonstrate the many options for the proper and attractive use of local building materials. Research will result in more options. An example is the development of pre-stressed masonry work, allowing for greater span widths.

Building materials should apply to different functional qualities. But the use of good materials does not automatically guarantee proper functional quality. It fully depends on the detailing and the realisation. Generally, materials must provide for a good thermal and sound insulation, etc, and also require only simple maintenance.

Another point is to ensure clear and simple detailing and construction, taking into account the local circumstances and qualities. In Peru, for example, the use of fresh timber for construction is common. This causes changes of dimensions once placed in situ. However, improper detailing, such as an ill-fitting sill for a window frame can cause problems, especially when it rains.

The occurrence of disasters will cost lives and will damage the environment, as well as capital, materials and energy. The Netherlands sometimes faces disasters caused by flooding of rivers. We are now at the stage of forbidding construction in low-level areas, because there are alternative safe locations.

In Peru there are occasional earthquakes and earth slides. Poor people construct their houses against the mountains on the soft subsoil, for a number of reasons. During heavy rainfall or during an earthquake their houses are easily destroyed creating an unsustainable situation. This situation can be prevented in various ways: (I) By making master plans with proper locations for buildings, roads, drainage, nature, etc. which have to be implemented. (II) By forcing people to use proper building systems, which can resist earthquakes. Although this does not cost extra money and although the knowledge is available, these measures are not taken or made effectively (see further below).

For earthquake resistance certain forms and layouts for housing are predetermined (for example symmetry, limited openings, etc.); this leaves little room for a specific architecture. By building on more stable soils, structures are less liable to suffer damage, allowing for more variations in form and shape. The variation in form can also be sought in other elements than just the basic structure. This can be kept simple as a result. Proper architecture means good detailing, providing for more comfort and resulting in less maintenance. In this context, bad roofing is one of the most frequently mentioned complaints (Dijk, 1998).

By improving the architecture and the appearance of a building and providing good quality, people have more incentives to stay in the house where they are living, thus preventing vacancies, drastic changes or demolition.

In Peru people have a tendency to copy architectural housing styles from Miami-USA, as they see those on television. Odd structures are built, which have nothing to do with local architecture. By recognising the local values and by making designs according to these traditions, the quality of the neighbourhood can be improved. People will feel more at home.

Improving the layout and optimising the floor area result in lower volume for a building, reducing the cost of materials, heating, cooling, etc. By sharing walls with the neighbours, the quantity of materials can be reduced. The reduction of the ratio external surface / volume of the building results in a smaller maintenance area.

In the Netherlands we have succeeded quite well in applying insulation. In Peru this has not played a role so far, because people are less disturbed by cold and noise in their culture. In the Andes, the coldness affects all activities after sunset. Because of the way of living and due to the level of development, this has not disturbed people as yet. However by improving economic conditions, they may want to improve their productivity and want more comfort. Through better detailing, the latter can be improved at no extra cost.

The access to light and solar heat can be improved if details are changed, as is the case with the frequent use of a small lean-to roof above the windows and doors for protection against rain. In general the building should have abilities to accommodate future changes of use, without involving major forms of demolition.

Sometimes a low functional quality is a result of last minute decisions. Fig.1 shows a detail of a house recently built in Cusco. The walls on the ground floor are made of adobe blocks and of reed (quincha) on the first floor; there are poles for the supporting structure and the roof consists of roman tiles on a cake of mud on top of reeds. Due to last minute changes, it was decided to add a sun lounge on a spot where a balcony had already been made. Naturally, the connection between the balcony and the roof of the sun lounge causes a lot of problems, especially when it is raining.



Fig. 1. Errors in the construction due to bad planning (Photo Erkelens)

## **TRANSFER OF TECHNOLOGY FOR IMPROVING SUSTAINABILITY**

In the above we have seen a lot of positive and negative examples related to sustainability in different countries. Transfer of certain technologies both ways can play an important role. However this can be problematic and should therefore not be done blindly but in close co-operation and with the consent of the parties involved. Although solutions for problems are often simple and at hand, the proper transfer of technology is found to be very difficult. This opinion is based on my experiences in Peru and Kenya.

The IIUR has a project to transfer tested technologies for earthquake-resistant earthen buildings (DUT-Delft). The tests resulted in simple measures to be taken for existing and new low-cost adobe housing, such as timber reinforcements in the corners, the use of chicken wire in the walls and ring beams made of timber or concrete.

Plans were developed for the construction of a few demonstration houses. However, it turned out after lengthy meetings that both authorities and people were not interested in this theme. The basic problem was how to convince people to apply these findings in their own houses, as they believe in acts of God in the event of an earthquake.

This happened at a local level. For the transfer of technology between countries the problem is even bigger. You cannot simply dump a technology. (There are more reports of bad experiences with the introduction of special adobe blocks and reeds to improve the resistance to earthquakes).

Another example can be taken from Kenya, where there were trials for improving the departmental structure of Ministries for Housing and Works. In retrospect, the posting of Dutch experts in the seventies was not a successful operation for the transfer of the Dutch housing technology. On the contrary, it hindered the development of a national housing policy (Erkelens, 1991).

Exchange of technology or technology transfer may help countries to learn from each other to achieve more sustainability. When we compare the situation in the Netherlands and Peru, we find that the latter, as a LDC, has the advantage of being “retarded” in its development. It is polluting at a far lower level and can more easily satisfy requirements for sustainability although they too, have to rectify on-going developments and trends. But although this may cost less money than for developed countries, because of their fragile infrastructure, the correction of the situation causes many problems and costs much energy, but more in the field of education of the people.

In conclusion, transfer of technology is not a simple solution to existing environmental problems. This applies also for the Dutch situation. The Netherlands is facing a huge waste problem. The building and construction industry contribute to a great extent to this problem. One of the options would be using loamstone in building – as is done abundantly in Peru. The technology is known, the loam is available, but the application of it is neither feasible nor accepted. The tendency is to continue with the existing building materials such as bricks, concrete, timber, etc.

Accepting this situation, but at the time contributing to solve environmental problems, has led to a research project on waste reduction in renovation and maintenance projects.

## **SUSTAINABLE RENOVATION AND MAINTENANCE**

Although a lot can be learned through the exchange and the transfer of some technologies, the examples presented earlier are not sufficient for the Dutch situation to achieve sustainability in Maintenance and Renovation.

As mentioned earlier, part of the contribution to sustainability lies in closing the life cycle of materials (closing the loop). A solution can be found in the application of the so-called IFD concept. IFD stands for Industrial, Flexible and Dismountable. When this is applied in new construction, at the time of maintenance, renovation or demolition, components can be simply removed, maintained and reused and replaced without creating waste.

Up until now, only a limited number of IFD buildings have required renovation. Today we face the renovation and maintenance of housing and utility buildings, which have been constructed according to the “classical” principles. These types of buildings are the cause of a tremendous amount of waste when renovated, maintained or demolished, because of the building systems, materials and components applied and methods of jointing and assembling.

The Technische Universiteit Eindhoven has started to research this phenomenon and is executing a study on the flow of materials and waste of renovation projects to come up with recommendations to reduce this waste and materials flow.

Fig. 2 shows the desired theoretical model for the flows. The materials / residues resulting from demolition will be reused (eventually after repair) either for the same application (A) or for another purpose (B), preferably in the same project. The remaining required materials (and components) consist of recycled (C) or renewable ones (E). The output consists of materials for recycling (C) and - limited to zero- waste (D).

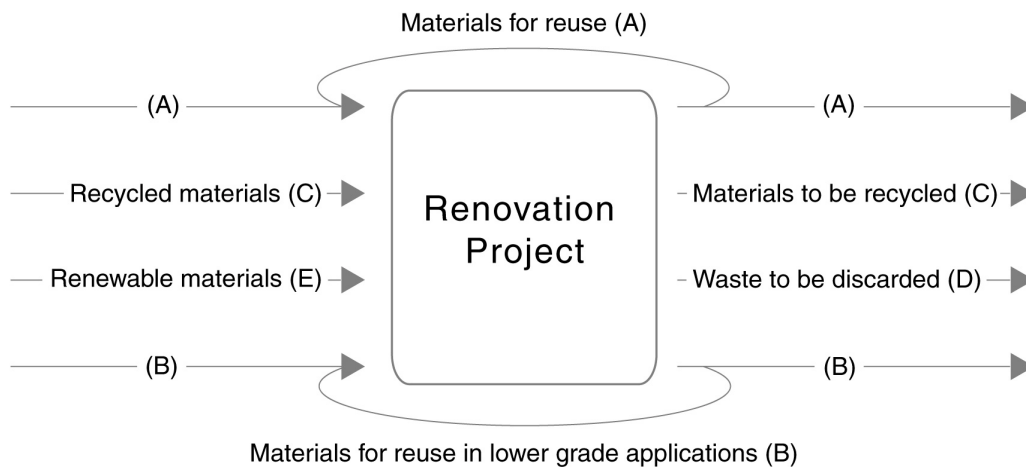


Fig. 2. Materials / components flow in a sustainable renovation project (Erkelens 2000b)

A study of new housing (SBR, 1998) has already indicated that the production of waste and residues can be reduced by 41% if the building process is planned and monitored closely.

In order to achieve these results in renovation projects, the building process has to be changed at certain stages: Prior to the development of a plan for renovation, an inventory has to be made of the building materials and components that likely to be removed from the building. This gives a theoretical list of materials and components that will be present after demolition. The method of demolition very much determines the quality of the resulting materials and components: whether these will be of the category (A), (B), (C) or (D).

The next step is to make a design for a renovation, taking into account the potential out-flows of materials and components. It should be noted that even a minor change in design might lead to a considerable reduction of waste.

We are aware that this study may be pretty complex. It will first involve the on-site analysis of the output. The next question will be whether or not the output can be reused. It should also be checked whether it was necessary to demolish or remove this material or component, or whether there are other possibilities.

The research will be executed on a housing project in the city of Eindhoven, involving 240 housing units in which the roof, internal walls, the kitchen and the bathroom will be renovated see Fig. 3 . During the process, daily on-site measurements will be taken, (Erkelens, 2000a).



Fig. 3. Housing complex under renovation (Photo Erkelens)

## CONCLUSION

Based on the above, the following conclusions can be drawn:

1. Although there exists important differences in culture, climate, techniques, etc. countries can learn from each other.
2. Most of the building techniques developed in one country need adaptations and acceptance in order to make them appropriate in another country.
3. The reuse of materials and components is still at a low level in renovation.
4. On-site investigation of the qualities and quantities of the square metre packet and the types of joints of an existing building allows for better design decisions for sustainable renovation.
5. However sustainable construction and renovation is only possible when the parties involved are motivated to do so.

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