The Use of Natural Materials for Construction Projects –
Social Aspects of Sustainable Building: Case Studies from
Australia and Europe

S Burroughs1 and J Růžička2
1 Remote Sustainability Consultant, Australia
2 FCE CTU in Prague, Czech Republic

drsteve@drsteveburroughs.com.au, jan.ruzicka@fsv.cvut.cz

Abstract. The three pillars of sustainability are the economic, environmental and social pillars. To achieve sustainable construction projects, these three priorities must be balanced. Considering social aspects is of equal importance when considering the design, materials and technologies used in buildings. The increased use of naturally based materials from renewable sources using traditional techniques is common in sustainable buildings and can help balance some of the social aspects. Building with traditional technologies such as compressed earth blocks (CEBs), rammed earth, adobe, or strawbale technologies is a viable option to conventional construction methods when the structure meets modern scientific and engineering standards. High-quality, sustainable buildings are achievable using local resources and local labour. This paper presents case studies from remote Australia and Europe and shows the social and environmental impacts according to the technology used. Prior consideration of the social aspects can result in the improvement of the sustainability of the building.

1. Social aspects of sustainable building in wider context

The three pillars of sustainability are economic, environmental and social. Social issues for building projects are still mainly related to the internal microclimate and health, comfort, satisfaction and well-being of the occupants. Quality assessment in those parameters helps to improve the quality of buildings, but it still does not cover the broader influence of the construction process to society.

The three pillars of sustainability are economic, environmental and social. Social issues for building projects are still mainly related to the internal microclimate and health, comfort, satisfaction and well-being of the occupants. Quality assessment in those parameters helps to improve the quality of buildings, but it still does not cover the broader influence of the construction process to society.

In economics, the need for implementation of broader matters other than hard, measurable features like "profit" and "loss" was recognized in the late '80s by Edward Barbier [1]. For example, a corporation shows a sizeable financial profit, but causes massive damage to the environment through mining sources or producing air pollutants. The local government must spend more money on increased health care and remove the environmental burden. This imbalanced state when one side has an enormous profit, and the other hand has to solve the damages does not lead to economic growth. Barbier defined environmental, economic and social features as parts of sustainable economic development. These three aspects of sustainability were introduced by John Elkington [2] as a "triple bottom line", which is
a framework used by large corporations to evaluate their performance in a broader perspective to create higher business value [3].

Similar situations can be drawn shown in the construction industry. In many cases, only the measurable features of the sustainable building such as embodied emission of used materials, the energy consumption of the buildings, the ratio between non-renewable, renewable or recycled materials are considered. The broader economic, social and environmental aspects must also be covered to determine the true sustainability of the building.

In 1999 Agenda 21 for Sustainable Construction (CIB Report Publication 237) was introduced as a global framework with a detailed overview of concepts, issues and challenges for sustainable building. However, this document was based on extensive research outcomes from developed countries and determined by the economic environment in developed countries. Therefore a particular Agenda 21 for Sustainable Construction in Developing Countries [4] was commissioned as part of the Action Plan for further implementation of Agenda 21 and supported by UNEP-IETC. In this document key issues and challenges and research, objectives are identified.

In terms of innovation in building materials and methods, Agenda 21 for Sustainable Construction in Developing Countries points out the need of drastic reduction in the use of natural sources and energy-intensive materials such as cement, steel, aggregates and aluminium. Special attention is focused on the use of natural materials, materials with the lowest energy demand and recycled materials. Supporting the local economy is stressed.

All principals mentioned above can also be used in developed countries in a completely different economic environment. The examples below show various case studies dealing with "soft" economic and social issues.

2. Implementation of social aspects to building process

2.1. Social aspects of building process for developing countries

In Agenda 21 for Sustainable Construction in Developing Countries [4] the following critical issues related to sustainable building in economic conditions of developing countries are identified:

- Urbanization and rural development.
- Sustainability in housing.
- Education.
- Innovation in building materials and methods.
- Modernising the traditional.
- Gender equity.
- Financing and procurement.
- Governance and management.
- Needing a new model of development.

Regarding innovation in building materials and methods, special attention is stressed on the possible use of agricultural waste products and other biological materials as structural materials. Innovative re-use and recycling and also supporting the local economy is highlighted together with improving traditional materials and construction methods with modern processes and technologies. Also following main barriers as an uncertain economic environment, low urban investment and ability to pay for services, the lack of interest by stakeholders in the issue of sustainability were identified in the document. Sustainability is still not a priority in developing countries and one of the main challenges to put this topic on the agenda.

According to research results and lesson learned from demonstration projects Pocock et al (2016) proposes that planning, designing and building projects should incorporate the following social sustainability processes in the developing countries:
• Secure land in a way that is legal and sensitive to local culture.
• Engaging the community in the entire life cycle of the project.
• Designing with respect to the local culture.
• Designing for maximum efficiency of limited water supplies.
• Designing locally sustainable systems for energy and thermal comfort.
• Designing for safety of the occupants by incorporating local codes while acknowledging international standards.
• Using technologies that can be safely constructed by local population (given training opportunities) and using locally understood construction methods.
• Using locally unsustainable and affordable materials.

The importance of local and natural based materials and low and traditional technologies is apparent.

2.2. Implementation of social aspects of building process in developed countries

They are many situations where incorporating social issues into planning, designing and building process can bring positive synergies. Unfortunately, nowadays social aspects are underestimated by the professional community but still they are examples of positive synergies in a different social environment. The role of raw natural and local materials and traditional but labour intensive technologies is crucial as the following examples show.

The main idea of implementing social aspect to building process is to give the users a chance to fulfil their needs connected to:

• Housing,
• Employment.
• Higher skills and better position on the market.

These target groups are usually not economically strong enough, often dealing with the social, economic or other handicaps. In those cases combining suitable building technologies, local materials, training opportunities can create positive synergies and social benefits.

3. Social aspects in construction sector – case studies

3.1. Historical examples

In ancient history, there are projects recorded which fulfil social issues mentioned. An example which addressed the social aspects is the construction of the Great Wall of China built over 2400 years ago.

Another example so-called the Hunger Wall (Czech: Hladova zed) (Fig. 1) was built between 1360–1362 as a part of the fortification of the Lesser Town of Prague, today's Czech Republic by order of Emperor Charles IV. The wall was initially called Zubatá (toothed) or Chlebová (built for bread). The adjective Hladová (hungry) appeared after a 1361 famine when the construction works of the wall provided a livelihood for the city's poor. According to myth, the purpose of the wall was not strategic but to employ and thus feed the poor.

![Figure 1. The Hunger Wall built in 1360–1362 as a part of fortification of the Lesser Town of Prague, Czech Republic.](image-url)
Heimstätte Dünne in Western Germany (Fig. 2) is another example of the social building projects in history. The Heimstätte Dünne Society was established in 1907 as an evangelic building and housing community. After WWI there was a lack of building materials and the economic situation of many people in Germany was horrible. In 1923 Pastor Gustav von Bodelschwing built in the village Dünne his own house using special technique called “Lehmbröte”. The method was based on adobes adopted from East Africa where he was as a missionary. This project was a pilot and introduced a suitable technique for self-made construction. Till 1943, more than 300 houses using this adobe technique were built in the Westphalia region (Fig. 3).

![Figure 2](image1.png) Old picture from the construction of the family house using adobe technique “Lehmbröte” (left). Detailed structure of the adobe wall (right).

![Figure 3](image2.png) Adobe houses in Heimstätte Dünne, Western Germany.

3.2. Current case studies

3.2.1. Social Housing, Halls Creek Project, Australia. At Halls Creek (18.2°S, 127.7°E), a small settlement in remote Western Australia, a project is underway to provide housing using compressed earth blocks (CEBs) as the primary construction material using local soils (Fig. 4). CEBs are a viable alternative to conventional construction materials when the block composition and method of manufacture meet modern scientific and engineering standards and are using local resources and local labour, reducing the usual costs associated with construction in such regions. Material tests show that the local regolith/soil is very suitable in terms of particle size distribution and plasticity for CEB stabilisation and manufacture.
Local workers will be trained on site to make CEBs during the construction process, allowing them to develop skills and employment opportunities as well as contributing to the social and economic capacity of their community. Competing designs for the houses are being developed through modelling, minimising the need for mechanical cooling in the hot climate by reducing solar gain, using such features as overhangs, shading, window size and shape, building orientation, wall thickness, insulation, and passive ventilation. Walling systems simulated for external climate, energy costs, and cooling needs include single CEB walls, double CEB walls, and double CEB walls with insulation. The houses, when built, should provide structurally sound buildings that are sympathetic to the local environment, as well as having high sustainability both in terms of embodied energy and carbon as well as energy use during operation and occupation. Also, the houses are cheaper to build and buy compared with backfilled concrete block or steel frame and cladding houses.

There is a significant opportunity for indigenous involvement in the delivery of projects using natural materials, in which social outcomes are of high importance and can be achieved at the same time as environmental outcomes.

**Figure 4.** Halls Creek project, Western Australia (2018). Field lab testing soils (left). CEB production (middle, right).

### 3.2.2. Day Care Center, Chedrbí, Czech Republic

A unique project has been carried out in 2005 in a small village Chedrbí in central Bohemia, Czech Republic (Fig. 5). This project was initiated by Diakonia a Christian, non-profit-organization offering help and support for living in awkward social situations. Local Diakonia Centre in Caslav, which provides services for children and adults suffering from mental, physical, or combined disabilities needed a new small facility as a daily sheltered and social therapeutic workshop.

**Figure 5.** Project Chedrbí, Czech Republic (2005). Daily sheltered and social therapeutic workshop, self-made structure with participating clients suffering from mental, physical, or combined disabilities.

The project managers suggested the idea to build the facility as a self-made structure and to involve the Diakonia clients in the building process. The question was raised at the beginning of the project as to what building technique to use which would combine a secure construction method with maximal safety for the potential involvement of non-skilled client labourers suffering from mental and physical
disabilities. Light rammed earth used as non-load bearing filling in load-bearing timber structure constructed by the professional builder was chosen as a suitable solution. The clients were involved in ramming external walls. Light rammed earth to the thickness approx. 400 mm was used as a building envelope; the thermal properties are not outstanding but still sufficient for the building.

The social impact of this project was much more important that the technical performance of the building. All construction standards and requirements were fulfilled as meeting regular building process, including zoning and building permission, were obligatory.

3.2.3. Self Made Houses, Amayuelas de Abajo, Spain. This project of 10 private houses [6] finished in 2001 (Fig. 6) is characterized by its innovative earth building approach which combined both traditional and modern building methods. Consideration was also given to environmental issues, the eco-architectural design, advanced energy concept as well as its substantial social and economic impact. Local soil was used for self-made construction of load-bearing mud walls, production of adobes and clay plaster. Other environmentally friendly and recycled materials were used within the project. These included the reuse of bricks for protection from wind and rain, reused timber, and the use of local timber, lime, and gypsum. The architectural design was done to passive solar design.

Social and economic impacts of this project resulted in new opportunities in the region. Amayuelas is a small village in a rural, economically depressed Spanish area with only six inhabitants. The latest development was crucial for further development of the community. During construction, a group of workers was trained in earth building; eventually, they founded a small company and now maintain local earthen cultural heritage. Nowadays 20+ inhabitants live in the ecovillage and run own small eco-oriented business.

3.2.4. Social Housing in Germany. Many social housing projects were built in the last three decades in Germany which considered historical, social aspects. These social housing project, for example, projects in Hiddenhausen–Schweicheln, Diepholz, Willebadessen [7] from the late '90s, were built using earthen structures and traditional technologies. This decreased investment costs due to low-cost technologies. The locals were involved in the project. Participation of the long term unemployed and homeless clients in the whole building phase meant the locals developed pride in the building and a sense of ‘ownership’. The social training program also helped to teach discipline, responsibility and good working habits. Skills gained could lead to earth builder qualification within the training program, another part of the social agenda.

4. Discussion
Considering social aspects should be of equal importance when considering the design, materials and technologies used in buildings. Prior consideration of social issues could result in the improvement of the sustainability of the building and result in more comprehensive social and economic benefits as shown in previous examples. There is still a question on how to set criteria for assessing the social aspects in the complex quality assessment of buildings. Consideration of the social elements for specific conditions, whether in developing or developed countries, should be implemented.
Based on the evaluation of the case studies, the following criteria reflect the social aspect of sustainable building that should be included:

- Use of low tech and labour-intensive technologies which enable the involvement of local target groups in the process, promoting positive social impacts and giving sufficient time for training process
- Developed training program and training process for specific target groups should always be part of the socially oriented project; gained skills or final certificate can provide an advantage on the local market.
- Use of locally available raw materials and low-cost technologies as they embody the principles of the sustainable building including the economic, environmental and social aspect.
- Respect for local culture and traditions should be considered in project development, architectural and technological design and the choice of construction methods.

Those four groups of criteria, if done correctly, cover the social aspects of sustainable building. The next task is how to implement these into current assessment methods and assessments systems. Determining their relationship to other currently used sustainability criteria needs to be undertaken and adjustments made.

5. Conclusion
The use of raw natural materials such as clay, earth, straw, and quarry stone play a decisive role in the construction of sustainable buildings as they are environmentally friendly easy to recycle materials. They also can play an essential role in addressing the social aspects of producing sustainable buildings and should be included in the building quality assessment.

In general, the overall quality of the building is growing in line with increasing standards in fields such as energy consumption, quality of the internal environment, and the carbon footprint. Including the social aspects in the overall quality assessment of buildings will help to quantify the social impact of the building as we strive to build truly sustainable structures.

References
[1] Barbier E B, Markandya A and Pearce D W 1990 Environmental sustainability and costbenefit analysis Environ. Plan. A 22 1259–66
[2] Elkington J 1999 Cannibals with forks: the triple bottom line of 21st century business (Oxford: Capstone) ISBN 9780865713925.
[3] Slaper Timothy F and Hall Tanya J 2011 The Triple Bottom Line: What Is It and How Does It Work? Indiana Business Review Spring 86(1)
[4] Du Plessis C (ed.) 2001 Agenda 21 for Sustainable Construction in Developing Countries – First Discussion Document CSIR, Pretoria and CIB Rotterdam.
[5] Pocock J, Steckler C and Hanzalova B 2016 Improving Socially Sustainable design and Construction in Developing Countries (Int. Conf. on Sustainable Design, Engineering and Construction) Availilable online at www.sciencedirect.com Procedia Eng. 145 288–95
[6] Gonzales M J, Silva J and Valbuena F 2002 High technology linked to vernacular earth construction Proc. from Moderner Lehmbau 2002 (Fraunhofer IRB Verlag) pp 18–22 ISBN 3-8167-6118-6
[7] Beck K 2000 Social housing – built with earth Proc from Moderner Lehmbau 2000 (Overall Verlag Berlin) pp 114–7 ISBN 3-925961-32-1