USE OF PREFABRICATED CONCRETE INSTALLATION WALLS FOR SELF-BUILT EARTHEN HOUSING PROJECTS IN THE GAP REGION OF SOUTH-EASTERN TURKEY

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Abstract. The South-eastern Anatolian Project (GAP) region of Turkey has a need for the rapid development of residential housing projects for the resettlement of people made homeless by the rising water reservoirs of the Birecik dam established for hydroelectric power generation and irrigation. The construction technology utilised in such a project must take into account the climatic and socio-cultural conditions of the region, and consideration should be given to employment of the local manpower. To cover the housing demand, an earthen technology was developed resulting in a case-study building in cooperation with Prefabricated Concrete Company ‘KAM Beton’ in 1999 for the Urfa-GAP & BKI (Regional Development Administration – Turkey). Case-study building is a two-storied earthen house designed with a prefabricated reinforced concrete installation wall that contains the plumbing and electrical facilities required both for the kitchen and bathroom. Construction of the foundations has obtained government support. Prefabricated concrete installation walls are to be engineered and manufactured by private enterprise. The earthen walls of the self-built masonry building are to be constructed by the local home-owners. Urfa case-study building aims to study the feasibility of combining advantages of different construction techniques. It demonstrates that self-built earthen house can be used with prefabricated installation wall to meet the benefits both of local workmanship and industrialised construction technology.

Keywords: earthen construction, Alker, prefabricated concrete panels, installation wall, hybrid construction technology.

AIMS AND BACKGROUND

Istanbul Technical University has been working on improving earthen construction technology since 1978 (Ref. 1). Although it has been mainly working on gypsum stabilisation, in this paper cement stabilisation will be mentioned. Construction of the Birecik dam in the South-eastern Anatolian Project (GAP) region of Turkey has led to the need for resettlement. In addition, increased employment opportunities due to irrigation have raised housing demand in the area to about 300 000 units per year. In case of such a huge housing demand, while the government manages labour, equipment and materials, the following factors should be taken into account:

(i) building material and construction technology;
(ii) human health and environment;
(iii) cultural and social considerations.
Huge housing demand in a certain time often leads to the use of industrialised technology. In fact, prefabrication in the housing sector was developed to meet the housing demand in Europe after World War II. The aim of the industrialisation of building technology is to reduce workmanship, and therefore time and cost, to a minimum. However, completely prefabricated housing offers little in the way of employment to local populations, and it can cause a cut down of regional development.

While it is essential that costs must be kept to a minimum, this is not the only factor involved in successful housing construction vision. Equally critical when planning rapid-construction large-scale housing projects is sensitivity to the cultural heritage of the region, social needs, and the promotion of environmental and human health issues. Combining prefabricated elements with local earthen self-built house construction can be an alternative providing speed, regional economy, and ecological sustainability.

SURVEY OF GAP REGION IN BUILDING TECHNOLOGY AND CLIMATE CULTURAL AND SOCIAL CONSIDERATIONS

The traditional construction materials of the GAP region are stone and earth (Fig. 1), which are suitable for the harsh climate. More recently, however, local people have been using manufactured materials such as hollow concrete blocks and bricks (Fig. 2) where the mechanical properties are not sufficient for structural demands and physical properties are not sufficient for indoor climate quality.

![Fig. 1. Halfeti, unique stone building under the water of the Birecik water reservoir](image)

HUMAN HEALTH AND ENVIRONMENT

In the GAP region, the mean value of the day time temperatures in the summer ranges from 45 to 50°C, while the mean value of night time temperatures ranges from 24 to 28°C. Temperature on the sun-facing walls rises up to 60°C and they radiate heat into the interiors. While inside of the house is uncomfortably hot at the summer nights, home-owners generally go up to the flat roofs for sleeping, and face
the risk of falling down from the roof. Use of earthen construction material with thermal insulation capacity can contribute to the quality of life in GAP region.

![Fig. 2. GAP area, new Gozeli building constructed with concrete hollow blocks](image)

**Fig. 2.** GAP area, new Gozeli building constructed with concrete hollow blocks

![Fig. 3](image)

**Fig. 3.** Earthen case-study building, constructed for Urfa Regional Development Administration 2000, GAP Area – Turkey

**BUILDING MATERIAL AND CONSTRUCTION TECHNOLOGY**

One-third of the world population lives in housing made of earth. Material for earthen houses can be found easily and enable local employment. Due to its physical properties, earthen material creates healthy indoor and environmental sustainability.

For many years earthen material has been out of market in the industrialised world and thus has not been benefited by the research and financial support of the construction sector. Recently though globally, due to environmental concerns as well as the emergence of such disciplines as ‘Green building’, earthen construction has undergone a revival. This demand paves the way for developing a new earthen construction technology.
The policy of the South-eastern Anatolian project of Regional Development Administration (GAP BKI) addresses the resolution of housing demand as follows:

(i) encouraging self-help by paying for housing costs or offering credit;
(ii) establishing new state housing settlement prior to resettlement of displaced populations.

In the Halfeti project (a town at GAP area), the construction of resettlement housing was carried out by the state alone, whereas in the Goezeli village project the residents themselves carried out the construction. Both examples could have benefited from a suitable mass housing construction system utilising local earthen material.

CONSTRUCTION TECHNOLOGY

Combination of prefabrication and earthen construction technology has been used. Obviously, the benefits of each individual construction method and their use in combination must be carefully considered along with their suitability for the requirements of this particular project. The aim of the industrialisation of building technology is to reduce workmanship, and therefore time and cost, to a minimum. Prefabrication is such a method that can be used with other suitable building techniques as a hybrid technology. In the case of the south-eastern Anatolian project, locally constructed earthen houses with a prefabricated installation wall have been developed to provide the suitable hybrid technology for the needs of the area.

QUALITY OF EARTHEN MATERIAL

Used as a building material, earth has three main disadvantages: it is vulnerable to moisture, has low strength, and is labour-intensive. The properties of soil vary depending on grain size proportions and mineral content of clay. Stabilising can modify the properties. There are different stabilising techniques such as mixing additives or compacting. Cement, gypsum and asphalt are mainly used for earthen stabilisation. However, cement stabilisation will be used in this case study.

ITU-GAP CASE-STUDY BUILDING

EARTHEN MATERIAL PRODUCTION

Today the technology of concrete production can be adapted to earthen construction. In that concept there are three common methods for the construction of earthen walls:

1. Using bricks or blocks of unburned earthen material produced manually or mechanically.
2. Compacting earth directly into a wall mould manually or mechanically.
3. Shooting earthen material into the wall form or mould.

Earth shooting is an ultimate rapid technique, similar to ‘shotcrete’. Production capacity can increase to 45 m$^3$ per day. In this case-study building, mechanised block production technique has been used. The soil excavated from the ‘Urfa tunnel’ construction at the Ataturk dam, Turkey, has been used for block production. It is mainly a mixture of limestone and clay. Limestone aggregates form a weak bond with a gypsum as a stabiliser. Therefore, the soil has been stabilised with cement in the GAP case-study building (see Fig. 3). Cement-stabilised earthen blocks have been manufactured in a plant at a rate of 3000 blocks/day. The case-study building needs a total of 60 000 blocks. Exterior load-bearing walls are 45 cm thick and interior walls are 30 cm thick. ‘Specification for Structures to Be Built in Disaster Areas’ issued by the Ministry of Public Works and Settlement for this type of construction has been complied with throughout the project design process.

![Fig. 4. Reinforced prefabricated installation wall between kitchen/bathroom in earthen case-study building plan (GAP Region Development Administration, Urfa –1999–2000)](image)

ARCHITECTURAL FEATURES

Earthen case-study building is designed for housing people displaced after the Birecik dam construction. The design is similar to the existing government flats of Urfa – GAP employees. Construction of this case-study building began in 1999 and was completed in 2000; the building entered immediate use as accommodation. The two-storey building has two flats on each floor. Each 100 m$^2$ wide flat consists of
three bedrooms, a living room, a kitchen and a bathroom. Figure 4 shows the plan of the building. The continuous foundations are made of reinforced concrete, as are the stairs, floors, and roof. The reinforced concrete floor between the two levels serves as a diaphragm, giving the building additional stability. The wooden roof is structured on concrete roof slab and is covered with tiles. As shown in Fig. 5, both the kitchen and living room are faced with balconies. Main exterior walls are built of earthen material, which prevents energy loss compared to hallow blocks.

![Plan of the building](image1)

**Fig. 5.** View of earthen case-study building (GAP-Urfa–1999–2000)

Concrete roof section is insulated with Styrofoam as much as the isolation value in exterior wall. Kitchen and bathroom are designed to be side by side so that the prefabricated wall can be located in-between. Building has a central heating system. The pipes for the sanitary water system of the case-study building are all plastic and the kitchen and bathroom floors and walls are tiled with ceramics. In the living areas of the house the flooring is linoleum and the walls are rendered and plastered.

![Diagram of building section](image2)

**Fig. 6.** View of earthen case-study building (GAP-Urfa–1999–2000)
Fig. 7. View of earthen case-study building (GAP-Urfa–1999–2000)

Fig. 8. View of earthen case-study building (GAP-Urfa–1999–2000)
PREFABRICATED INSTALLATION WALL

The installation wall situated between the bathroom and kitchen contains all the clean and wastewater plumbing and electric installations required for both rooms. Kitchen side of the installation wall supplies a kitchen sink and electrical appliances, while on the bathroom side it supplies a shower, closet, washbasin, water heater and washing machine. The prefabricated reinforced concrete installation wall is 300 cm bright, 651 cm high and 12 cm thick and is based in the foundation of the building. Figures 6 to 9 show cross-sections of the building, plan of the bathroom and kitchen, wall of the bathroom, and the prefabricated installation wall, respectively. Prefabricated wall based on concrete foundation support the first floor and roof slab.

CONCLUSIONS

Urgent resettlement needs have created a massive demand for housing in south-eastern Anatolian project region of Turkey, due to rising waters of the Birecik dam as well as new job opportunities due to irrigation.
The ITU earthen case-study building has been designed to demonstrate how a prefabricated installation wall combined with earthen construction technology can provide large settlements while maintaining local workmanship.

The material for earthen building is excavated from the Urfa irrigation tunnel, which connects the dam to farming lands. The source of readily available soil is limestone. Since limestone and gypsum provide low strength composite, soil has been stabilised with cement.

The case-study building has been designed as a two-storayed and four-apartment house. Earthen bearing walls are 45 cm thick for the exterior (supplying heat insulation) and 30 cm thick for internal walls. All load-bearing walls, flooring and stairs are based on a concrete foundation. The design of two prefabricated installation walls of the building contains the piping and cabling necessary for the kitchens and bathrooms of two apartments. Besides the prefabricated installation wall, which was to be manufactured by qualified technicians in the factory, all the earthen walls are planned to be build with local workmanship.

The case-study building in GAP region, as a model for large housing projects, has fulfilled the criteria of: building material and construction technology, human health and environment, cultural and social considerations. Prefabrication and traditional local building technology, which has been tested at project level, can contribute to sustainability.

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REFERENCES

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