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Case Studies of Citizen Experiment with Unconventional Construction Technique

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ABSTRACT: "*Many a Little makes a Mickle*" and this study first defines the word unconventional w.r.t. construction technique and then documents an individual citizen's effort to achieve sustainability by adopting unconventional construction technique. A citizen is a person who lives in a particular place. A citizen who has a sense of belonging responds to the place and community by contributing physically, socially and/or economically to it. These citizens also inspire architects to sensitize other clients to adopt such building practices that are contextually feasible, economically viable and help achieve sustainability.

I. INTRODUCTION

The idea of sustainability has always aimed at benefitting the masses, to be achieved en masse, but it is a fact that, "*Many a Little makes a Mickle*". Although there are very few people who do something regarding this in the hope to make the world a better place, most people wait for the governance to come through with solutions. The idea is that every individual counts, any or every, small or big step taken for sustainability would benefit many others. This stand true for the building industry too.

Through history the human kind has shown both individual and communal enterprise. Architecturally too, history shows the work of individual architects as well as the communal enterprise. Pietro Belluschi defined communal architecture as "a communal art, not produced by a few intellectuals or specialists but by the spontaneous and continuing activity of a whole, people with a common heritage, acting under a community of experience." (1). It can also be stated as the '***Conventional'*** way of building, which is considered acceptable by the society. In a community today, building technology focuses on societal acceptance or current trend. Conventional, for community and architects alike, now means the use of a limited set of building materials and technologies, which have societal acceptance, even if they were contextually incorrect. Therefore, in this paper the working definition of **"Conventional"** is the methods that are largely practiced in the building industry and construction technology, these practices are mimicked everywhere without much consent to the site and context.

The notion of being accepted and respected in the society has thus, narrowed down the idea of sense of belonging, to fit into a pattern, sometimes forgetting traditional wisdom and environmental concerns. Such is the state of the building industry that it has come down to a point where it is now '***Unconventional'*** to use such building materials and technologies, using wisdoms of the past. And the working definition of **"Unconventional"** is practices that are based on the idea of not following the said conventional methods and technologies but building something that is more appropriate to the time, place and need or contextually correct.

"Citizen" is defined by Oxford dictionary as a person who has a legal right to belong to a particular country. It also describes as an individual who lives in a particular place. He does so because of the sense of belonging to the place, to its community and its built and natural environment. An individual who has a sense of belonging responds to the place and community by contributing physically, socially and/or economically to it. The individual/ citizen is also the client of the building industry.

This study is an effort to document a citizens/ individual effort to achieve sustainability by adopting unconventional construction techniques.

II. METHODOLOGY

To understand how an individual/ citizen has made an effort towards sustainability, the study chose to document two projects in Rajasthan. The cases were unique in their approach as were the clients. Table 1 shows the criteria of choices of case study.

The citizens were then interviewed to understand their motivation, approach and objective of undertaking an unconventional building methodology, which was then weighed against present researches on the said technologies. The analysis is qualitative and the conclusions are oriented towards answering the following question:

Whether the choices made by the said citizens were effective, and how could professionals contribute in helping the society benefit by the use of unconventional building techniques.

Table 1: Criteria of Selection for Case Studies.

	CRITERIA				
	Citizen/ Client	**Geographical location**	**Time of construction**	**Use of building**	**Type of construction: conventional/ unconventional**
Case 1	Citizen by Birth	Jaipur	Under Construction started 2016	Naturopathy Centre	Unconventional – PET bottles and Self Supporting vaults
Case 2	Citizen by Naturalization	Mt. Abu	Completed 2000	Residence	Unconventional – Mud Brick Construction

III. PRESENTATION OF CASE STUDIES

Case Study: Naturopathy Centre, Jaipur

About the Client. Mr. Anil Sharma is a retired marketing manager, and a graduate in science from Delhi University in 1974. His passion lies in construction, as he mentions the project to be his 6thbuilding project till date.

Figure 1: PET Bottle in Walls and Columns

Figure 2: Under Construction Vault Roof

The inception of the idea of building a naturopathy centre started taking shape after witnessing his parents being involved in naturopathy and yogic practices. His mother, as the client portrays, used to practice naturopathy in her time. She was a creative person and always believed in the idea of re-using things rather than throwing things away. His passion for reviving building techniques of the past played a role in this project.

About the Project. The idea behind this naturopathy centre was to go back to nature, as in the past. With progress human civilization has forgotten some of the established wisdoms in building technology. This centre is a physical manifestation of reviving such wisdoms and to discover new options of recycling which can be put to use in the building industry. To creatively reuse objects and achieve success was this client's family attitude, which were the driving factors that inspired him to opt for these unconventional methods and techniques.

The client being a layperson to the industry, opted to learn from the internet. The project has wall and structural systems built with sand filled PET bottles and roof systems derived from various brick vaulting in history. He tried many different keywords to get the correct and relevant information.

Figure 3 PET Bottles ready for Installation

Construction Techniques adopted: Walls and Columns: PET bottles filled with sand is a technique used for building walls in several African Countries since last 16 years, and many of the Indian universities have done researches on the same topic. The reason to use these plastic bottles was to propagate the idea of reusing instead of throwing away the plastic bottle waste. Since the idea is useful for ecosystem as well as would benefit many as far as constructing a new building is concerned.

Fig. 4.

Several thousand plastic bottles were used. Arranging plastic bottle in huge amount was a task for the citizen but his search ended at the railway station. One empty plastic bottle cost him Rs 1.10, adding on the price of labour for sand filling and carrying it to the construction floor it cost him for Rs 3.75. This price is about half the price of the bricks that is used in this project. Sand for filling up the bottles was from the excavation for an underground water tank for construction. Benefits of using these PET bottles were that it takes about 1.5 times the span covered by a normal brick.

Roofing system: For the naturopathy centre is inspired from an idea of reducing heat gain from roof. He came across these age old techniques of self-supporting vaults and domes built by bricks.

Fig. 5.

He learnt about different types of roofing systems and has incorporated in his design. The centre houses 5 different types of baths and each one has a different type of roof. A barrel vault, simple Vaults, a Timbrel Vault (Boveda Catalan) and Boveda Extremena.

In the span of 8' by 10' a total of 1000 bricks are used, that sums up the cost at around Rs 7000. Along with the cost of a mason and a helper. And only 1 to 1.5 bags of cement was consumed.

Analysis. PET bottle construction has been used for the walling system in this centre. PET bottles are 20 times stronger in terms of strength, seepage of water through plastic is not an issue, time taken for construction is around 15% lesser (2) (3).The cost effectiveness of using plastic bottles instead of bricks is also on a positive side since PET bottle constructions is more than 45% cheaper than a conventional brick masonry (2). Since, bottles are collected from waste collection source to be reused after end of first cycle, embodied energy involved is only for the transportation from source to site. Material processing i.e. sand filling is done on site, and sand was procured from site only which was dug out from an underground water tank. This whole process reduces the embodied energy of this material in this case. Although 15% wastage is considered in this case as well but wastage of the material is minimum or nil since material is flexible and less likely to get damaged during transportation, and loading unloading.

Roofing system in this project does not incorporate the cost of shuttering, re-bars, coarse and fine aggregates and labour and other R.C.C. roofing machinery. Only bricks and couple of cement bags along with a grinding machine has been used to construct these self-supporting vaulted roof system.

Material availability for the construction was a bit of a challenge for the client since this type of construction is not done in the city. Possibility of wastage in this case is more because this is the first time masons were building with such materials and techniques, hence scope of error was more resulting in relatively more wastage in initial days.

Although time taken to construct with these alternative materials is lesser as mentioned previously, but since it was the first time mason saw these techniques and methods. it was taking more time to understand and redo the wall or roof if there was an error in the first attempt.

Mr. Babulal is the Contractor and has been the head mason for this job. As he shares some working details of the project, his attitude towards learning these new methods and techniques is positive and he wishes to work and teach more about these technologies if given a chance.

Case Study 2

About the Client. Mr. Manfred is a German National, he has been visiting India since 40 years due to Brahma kumaris. Since the year 2000 he is permanently settled in Mt. Abu, India. He is a trained surveyor and a professional working in the industry for 30 years and did landscape architecture along with 15 other architects. Post retirement he has dedicated himself to the cause of the Brahma Kumari cult.

About the Project

This client built his residence, in the small town of Mt. Abu, Rajasthan. This case is the best example of a contextual design approach. Since the basic building material was procured, processed and used on the site only. Building material used is adobe or mud bricks, which is one of the primitive building materials known to man in today's time.

Figure 6: Plinth Construction for House

Fig. 7. View of house.

Although the idea of building a house was not there initially, his frequent visits to India and the Bhrahma Kumari way of life started the idea of the house taking shape. In order to be true to nature and give back to the environment he asked theGerman architect Professor Gernot Minke to design the house contextually. The idea of earth construction emerged. The project was granted permission along with a master plan for Gyan Sarovar and a Solar house. Master plan was proposed in mud construction, and since this region is an eco-sensitive zone and houses many wild life species, it was granted permission on the basis of that. This citizen's drive to push this project beyond all odds, which also included local population's pressure of using conventional technologies, saw this residence being built.

The complete process of extraction of raw material to processing and its end use was conducted on site only, raw material was procured from the neighbouring vicinity of around 50 meters. Only use of R.C.C. in the whole project was for the beams.

The client has also created 15 water basins on the site since the house sits in a valley.

Figure 8: Making of Mud Blocks

Fig. 9. Vaulted roof construction.

Labour for the project were arranged by a local builder, Mr. Manoj. This was the first hands on experience to work with mud for the labours but they had experience of building the conventional way.

Building Details. As mentioned earlier that the material procurement and processing was done on the site only. Machine used to prepare bricks was borrowed from TARA and IIT Delhi. Machine had a capacity of moulding 2 bricks at a time and maximum of 1000 bricks a day could be produced with a single machine since it was to be operated manually. Biggest advantage with working with shade dried mud bricks was that if any brick was deformed or not in good shape, it could be remoulded again resulting in zero waste.

Mud mortar was used for the construction, and sample was prepared first to check the consistency with the proportions of 4:1 where 4 portions of soil and 1 portion of coarse sand.

Once it got finalised a bigger batch was prepared and the biggest advantage of mud mortar was that if certain amount of the batch could not be used that day it can be reused again in the following days.

Figure 10: On Site Drying of Mud Blocks

Figure 11: Interior view of the house

Scaffolding for the roof was of the size 4' by 2' and it was constructed in parts. One of the important to be considered for roof was its water proofing. The vault was layered with tar to water proof it. It has a guarantee of 4 to 5 years and hence, it needs maintenance and except this, house has never undergone any sort of maintenance work.

Analysis. Earth is the most important natural building material, and it is available in most regions of the world. It is frequently obtained directly from the building site when excavating foundations or basements. In the industrialised countries, careless exploitation of resources and centralised capital combined with energy-intensive production is not only wasteful; it also pollutes the environment and increases unemployment. In these countries, earth is being revived as a building material. Increasingly, people when building homes demand energy- and cost-effective buildings that emphasise a healthy, balanced indoor climate. They are coming to realise that mud, as a natural building material, is superior to industrial building materials such as concrete, brick and lime-sandstone. (4). The advantages of adopting earth construct in Mt. Abu were.

Properties

- Earth construction balances air humidity
- Earth construction stores heat: Like all heavy materials, Earth construction stores heat. As a result, in climatic zones with high diurnal temperature differences, or where it becomes necessary to store solar heat gain by passive means, earth construction can balance indoor climate.
- Earth construction saves energy and reduces environmental pollution. The preparation, transport and handling of earth construction on site requires only ca. 1% of the energy needed for the production, transport and handling of baked bricks or reinforced concrete. Earth construction, then, produces virtually no environmental pollution.
- Earth construction is always reusable when unbaked
- Earth construction saves material and transportation costs. Clayey soil is often found on site, so that the soil excavated for foundations can then be used for earth construction. Even if this soil is transported from other construction sites, it is usually much cheaper than industrial building materials.
- Earth construction is ideal for do-it-yourself construction. Provided the building process is supervised by an experienced individual, earth construction techniques can usually be executed by non-professionals. Since the processes involved are labour-intensive and require only inexpensive tools and machines, they are ideal for do-it-yourself building.
- Improving indoor climate. In moderate to cold climates, people usually spend about 90% of their time in enclosed spaces, so indoor climate is a crucial factor in well-being. Comfort depends upon the temperature, air movement, humidity, radiation to and from surrounding objects, and pollution content of the air contained in a given room. Air humidity in contained spaces has a significant impact on the health of inhabitants, and earth has the ability to balance indoor humidity like no other building material
- In terms of strength (compressive and bond), elasticity, plasticity, shrinkage, cutting radioactive, electromagnetic and ultraviolet radiations, thermal comfort, reduced heat transfer and having basic pH value, earth as a material is far superior to the conventional/industrial materials.

IV. CONCLUSIONS

The cases researched are very good examples of unconventional building technologies.

The first case is an attempt by an individual who is not associated with the building industry and second case was proposed and given shape by an international professional who showed more concern towards context and environment. Both the cases are completely different in almost all regards, whether it is construction method or location and context they are built in. One of the important differences is of the professional monitoring, since first case is being executed without any professional guidance whereas second case was detailed out by Professor Gernot Minke of Germany, who has excelled in mud construction all over the world. Despite the dissimilarities of the case studies the thing that is common in both of them is the awareness and sensitivity of the citizen to the environment and the choice of going the unconventional way of building these structures.

The intention of compiling these cases is to bring forth the citizen's concern of trying to adopt the unconventional building technology and achieve sustainability. These citizens also inspire professionals to sensitize more citizens to adopt such practises that are contextually feasible, economically viable and help achieve sustainability.

The choices made by the citizens were as per the context and environment friendly in their respective environments, hence proving to be effective in both the cases.

There is a growing environmental consciousness and an awareness that not only do industrially produced materials require unnecessarily high energy inputs; they also consume scarce resources while producing pollution. Another factor is the desire to live in a balanced and healthy indoor environment. It is an architect's job to educate a client regarding better options in almost every regard. To research and adopt wisdoms of the past even if it is an unconventional method should be the professional approach thus benefitting the client and the sustainability issue at large. An attempt to increase unconventional practices would help in making these technologies conventional, this will simply mean material availability is better, labour are more skilled and this would result in lesser time, cost and better quality constructions.

This study caters only two such cases, but a more extensive study could be done if more such examples are documented. This would help in analysing the impacts that these individuals have made, and also getting to know how much people are taking initiative at an individual level to make a difference.

Another scope could look at the acceptability and attitude of people towards such unconventional technologies. Newly developed and successfully tested earth construction techniques and other recyclable materials are waiting to be adapted and implemented in countries where they have not yet been tried. In order to disseminate these techniques, guidelines should be developed and training courses offered. The practicability of these techniques will have to be demonstrated not only with residential projects, in particular with low-cost housing, but also in public buildings such as hospitals, schools, and office buildings. This would show that, if used correctly, unconventional techniques, technologies and materials are a long-lasting and economical option that is easily available and easy to handle and is capable of creating even prestigious buildings.

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