LOW COST HOUSING CAN BE TECHNICALLY SOPHISTICATED AND ARCHITECTURALLY ATTRACTIVE

Latifa Mohamed Wafa

Department of Architecture and Urban Planning
Faculty of Engineering, University of Tripoli - Libya
Email:- Latifa.wafa@arch.edu.ly

الملخص

يعتبر المسكن من أهم العوامل المساعدة على تكوين الأسرة وسلامة نموها، حيث أنه يوفر المأوى لأفرادها ويؤثر إيجابيا في سكينتها النفسية واستقرارها الاجتماعي والاقتصادي كما أنه يعد أهم وأثمن ما تمتلكه الأسرة في حياتها وحيث إن الحصول على المسكن اللائق الذي يوفر احتياجات الأسرة يتطلب في الغالب جزءا كبيرا من مدخراتها، فإن خفض تكلفته بما ييسر عملية الحصول عليه وامتلاكه هدف إنساني نبيل وتنموي مهم في كل دول العالم ومن بينها ليبيا. ورغم التقدم الكبير الذي طرأ على تحسن ظروف الإسكان في أجزاء كثيرة من العالم، فإن أكثر من بليون شخص في العالم لازالوا يعيشون في مساكن غير ملائمة، وحصولهم على الخدمات الأساسية محدود أو معدوم ومعظم أولئك يعيشون في البلدان النامية. لهذا تظهر الحاجة الملحة لتقديم وتبني نماذج لمساكن توفر احتياجات الأسر، تستفيد من تقنيات البناء المتطورة، وتنسجم مع التطورات المستقبلية.

تقدم هذه الورقة عرضاً مجملاً لثلاثة أنواع من التقنيات المتطورة مختارة من بين عشرات أنواع التقنيات الموجودة التي تمكن من بناء مساكن منخفضة التكلفة وذات جودة عالية وطابع معماري جذاب.وتتميز بأساليب ومقارنات مختلفة عن بعضها البعض.

ABSTRACT

Access to safe and healthy shelter is essential to a person's physical, psychological, social and economic well being and is a fundamental part of basic livelihood. However, greater numbers of the world population live either without or very temporary shelter. Poverty and limited accesses to resources have compelled people to look for low cost housing options. Low cost housing (LCH) in Libya and in many other countries is a noble cause with a sad history. As human beings, we generously support the broad goal of helping our less fortunate to acquire their own homes. New technology in the field of housing construction and the new approaches to the low cost housing (LCH) buildings problems will help to overcome these problems in terms of time and cost of construction which will solve housing shortage problems that face many developing countries including Libya.

This paper presents an overview of three selected low cost housing construction techniques. These techniques produce low cost housing, which can be technically sophisticated and architecturally attractive inside and out. Each technique is based on different concept and different approach to the housing construction.

KEY WORDS: Low cost housing; Sophisticated technology; Architecture; Social well being stabilized earth brick technology

INTRODUCTION

The sad fact is that modern research tools are more than adequate to do a reliable job and the best information become meaningless when heartlessly applied. Public housing, at least as we know in Libya and even in developed country such as United States, traps the designer with its minimum standards. The program data for low and moderate-income housing reflect our social philosophy toward housing and the poor: low income housing is equated with low cost housing (LCH), for if you are poor you have not done well; therefore, you do not deserve so much. As Pangora [1] stated, "We cannot continue to let land economic, in the realm of minimum standards and maximum saturation, determine the quality of life, this policy has clearly produced unsatisfactory results".

Public acceptance of (LCH) living, especially apartments type, has been undermined because many apartment complexes built by the government in this country since late 1960's were poorly designed for Libyan family's size and lifestyle. Many units are plagued by awkward layouts, small rooms, inadequate closet space and tiny kitchens. And if there's a balcony at all, it is likely to be too narrow to be of much use. Also many of them are poorly constructed. Too many of them have ordinary facades composed of cheap materials and shoddy details. Most of housing projects have unsuitable if not lack of, infrastructures such as water supply, plumping, paved roads and pedestrians' pathways and all surrounded by unattractive unpaved parking lots. Also the absence of buildings management led to fast deterioration of the apartment buildings projects in the country.

These views need to be changed if our society hopes to achieve the objectives of what is called "smart growth," and better built environment in unison with its natural surroundings. The change should come through good choice of projects sites, good design and lower construction cost, to attract young educated couples with limited income. New technology in the field of housing construction and the new approaches to the housing construction problems will help to overcome these problems in terms of time and cost of construction which will solve housing shortage problem that faces many developing countries including Libya, and at the mean time managing urban and suburban growth and improve existing communities, while, protecting the environment, conserving energy and natural resources.

This paper is a contribution to the efforts in promoting the application of new techniques in housing construction which could produce low cost housing by savings in construction time and money by using less but more efficient building materials. It discusses and explores three different new construction techniques available in the world market that can be applicable to the Libyan housing needs. The first technique is for housing and buildings up to three stories high in rural and remote areas. The second and the third of those techniques are suitable for low and medium high apartment buildings for large urban area. This paper will also present an overview of the selected low cost housing construction techniques. These three techniques produce low cost housing are technically sophisticated and architecturally attractive, but each is based on different concept and different approach to the housing construction. The primary purposes of this paper are to:

- Support and encourage sophisticated low cost housing technology in any country where there is a distinct lack of conventional housing.
- Show that there are alternatives and technologies to build comfortable and affordable houses, and

- Show that Low cost housing should not be ugly and degrading.

LOW COST HOUSING SYSTEMS

Low Cost Housing is a concept which deals with effective budgeting and following of techniques which help in reducing the cost of construction through the use of locally available materials along with improved skills and technology without sacrificing the strength, performance and life of the structure. There is huge misconception that low cost housing is suitable for only sub standard works which are constructed by utilizing cheap building materials of low quality. The fact is that Low cost housing can be done by proper management of resources.

The recent initiatives taken at the national level to improve the quality of life of the citizens are in line with the aspirations of the people. Various housing projects are presently underway or in the pipeline. The costs for the provision of sufficient number of houses to those in need represent a major investment item in the national budget. At the individual level also, building costs represent a high item in the family budget. Traditionally, the basic methodology of constructing concrete houses for residential purposes has not changed over the last 40 years or so.

As one of its responsibilities to address technological and socio-economic issues, and technology related to quality of life, number of research centers initiated research projects on alternative construction technologies especially for less developed regions [2]. Low cost housing system works on the age old simple principal that less is often more, in other word less work is more satisfaction [3]. Also high-tech building system doesn't mean it should be expensive and complicated. Three different low cost housing systems will be presented in this paper. Each system applies different techniques and different materials, but they offer low cost housing and they are applicable to the Libyan situation. The systems presented in this paper are:

- Stabilized Earth Brick Technology (SEB)
- Tridipanel System (TPS) prefabricated polystyrene panels with wire mesh
- Integrated Building System (IBS), a building system that can be fabricated in a highly automated environment

This paper will discuss the concept behind each system, the technology applied, and the benefits of each system.

THE FIRST SYSTEM: STABILIZED EARTH BRICK TECHNOLOGY- (SEB)

"All the buildings (mud building) were pleasing to the eye…. They all had satisfying curving rhythm that seemed to come naturally when we designed for volts, but which straight lines and flat roofs hardly ever produced. Besides being cheap, it is also beautiful. It cannot help being beautiful." Hassan Fathy [4].

Earth has been the most essential building material since the dawn of human race. In modern times, earth has frequently been condemned as poor, archaic and primitive, yet it has passed the test of time proving to be a versatile and viable building material, adaptable to the most diverse cultures, conditions and climates. Earth architecture is physically comfortable, partly because of its very low natural conductivity of heat and partly because mud, being weak, requires thick walls. Stabilized Earth Brick technology- (SEB) had overcome this problem by treating the soil with ionic soil stabilizer.

This technology is very simple- an interlocking clay brick system, treated with ionic clay stabilizer formula. This alters the clay and improves its engineering properties

including compaction, density, bearing strength and safety (i.e. fire). This provides a low cost, durable product that can meet the needs of the millions of low cost housing units required annually around the world. This is not any ordinary block; it is a specifically engineered and designed interlocking system for maximum shear strength to withstand typhoon and hurricane strength winds. With many variable designs to choose from, there are no limits to designs, plans or finishes with a Stabilized Earth Bricks home, Figure (1) and Figure (2), [5].

Figure 1: Stabilized Earth Bricks are variable in many designs to choose from.

Figure 2: The bricks being laid with mortar, this is only necessary when laying the foundations, the rest of the wall is dry stacked [5].

This technology provides products and services to the housing industry including earth brick machines, which are fully automatic or manual modes. The machines are easily transported onto a construction site and can immediately produce high quality, interlocking bricks made from the local soil-(Production-10 blocks per minute). By using the unique interlocking features, machines allow "dry construction", i.e. no mortar is required to hold the bricks together. This is only necessary when laying the foundations, the rest of the walls are drying stacked. The Bricks produced are so strong they can be easily handled and immediately stacked for storage on the building site. It can be used within a few days of production. Stabilized Earth Brick machine, will allow for fast, reliable and low cost construction of high quality houses utilizing unskilled labor, Figure (3).

The construction of a 100 square meter house requiring 10,000 soil/clay brick, it can be achieved within a week and will be of the highest standard. The house will be heat resistant, sound proof and completely stable.

SEB M1 **SEB M2** **SEB M3**

Figure 3: Three types of Stabilized Earth Brick (SEB) Machines which can be easily transported on to a construction site.

To produce good quality bricks with Stabilized Earth Brick technology, the following procedures must be adhered to:

- A soil that contains 15%> percentage of clay, must be used, pure sand will not work. If inferior soil or clay is to be used, then a clay material will have to be imported and properly mixed with the in-situ materials.
- Mix the soil with the prescribed dosage of Road Packer Clay Brick Stabilizer per m^3 of material/soil.
- Adjust the hydraulic pressure of the machine to the type of soil and moisture used.

The Compacted Earth Brick allow one to use the most abundant raw material on earth, soil (which is usually free). It can be produced on the construction site, which negates the need for transporting the bricks and thereby, reduces the risk of damaging the already "paid for" bricks. The Bricks use only 0.2 of liter of Clay Brick Stabilizer per m^3 in the mix to achieve the most inexpensive, strong and most attractive looking wall. They are strong and highly compacted, of the highest resistance (>8mpa) and do not require the use of any reinforcing bars to build a completely strong durable dwelling of up to 3 stories (except in seismic areas).

Houses built by Compacted Earth Bricks are of quality so high and a finish so good that most of the builders do not plaster or paint the external walls. Furthermore, the majority of the low cost housing, because of the high standard and finish, can be left with the internal walls not painted.

A Compacted Earth Brick house is totally exothermic to the extent that neither the heat nor the cold will affect the comfort of the occupants. The occupants should decide that they wish to install air conditioning or central heating, than their electricity bill will be minimal. This type of housing is most suitable in rural areas and in the new planned of permanent statements -specially in hot arid regions in the country, also one of the advantage of SEB system - is that it response immediately and more dynamically in the unplanned event of natural disasters. It can be move into a declared disaster area and begin to provide the basic requirements for that community to return to a position of normalcy.

Benefits of the SEB Building System

SEB is low cost and it is one of the most energy efficient building systems for four important reasons:

- It uses the most widely available and least expensive building material in the world-earth.
- It has a host of environmental advantages over other building systems.
- It involves unskilled local people in erection of the buildings - thereby encouraging 'ownership'.
- It produces attractive buildings of high strength Figure (4).

Figure 4: With many variable designs to choose from, there are no limits to design, plans or finishes with an Enviro-Bricks home.

THE SECOND SYSTEM: TRIDIPANEL SYSTEM

The Tridipanel system uses prefabricated polystyrene panels with wire mesh that becomes a structural wall. Tridipanel is an environmentally friendly-recycled green product and has tremendous flexibility and is priced affordably.

It can be used in place of wood or metal-framed walls, masonry block walls or pre-cast panels. It is an excellent structural system that can be used in floors, ceilings, and roofs. The Tridipanel system saves construction time while providing greater structural integrity. As an eco-friendly low cost housing system, Tridipanels are manufactured with all recycled plastics and steel - no forest products are used. Tridipanel low cost housing system is safe and friendly to humans and wildlife.

Fabricated 3-D panels consist of a three dimensional welded wire space frame utilizing a truss concept for stress transfer and stiffness. Each surface of the wire space frame has a 2 inch square welded mesh pattern of longitudinal and transverse wires of the same diameter (gauge 11, 12.5 or 14), [6]. Tridipanel is extremely strong structural product consists of a super-insulated core of rigid expanded polystyrene sandwiched between two-engineered sheets of eleven-gauge steel welded wire fabric mesh Figure (5).

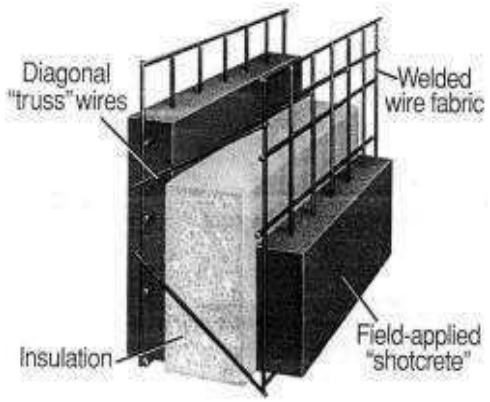

Figure 5: Detail of fabricated 3-D panel [6].

To complete the panel form process a nine-gauge galvanized steel truss wire is pierced completely through the polystyrene core at offset angles for superior strength and welded to each of the outer layer sheets of eleven-gauge steel welded wire fabric mesh. Once these three elements are joined, it end up with a three-dimensional lightweight panel that due to their characteristics makes them one of the strongest building materials one can find Figure (6).

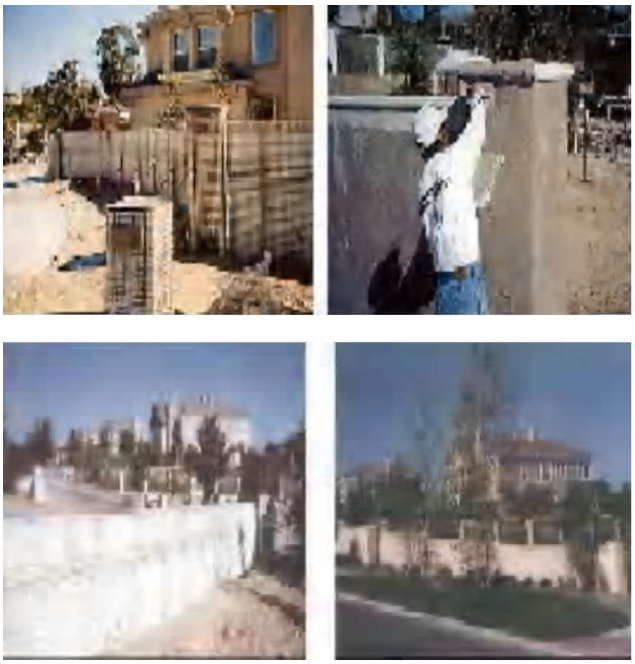

Figure 6: Flat mesh and wire mesh holds panels together until shotcrete is applied, architectural foam shapes of many styles can be applied over the Tridipanel.

Tridipanel is used for numerous building applications. It can be used in conjunction with all other conventional buildings materials. Tridipanel is an excellent product for building privacy walls around the home or building structure, with handsome good looks and great flexibility Figure (7).

Figure 7: Complete roof load trusses setting on 3-D Panels [6].

How Does Tridipanel Compare In Cost To other Building Systems?

The cost depends upon the design and finish of the project. Every structure is unique like a fingerprint; no two are alike. This makes analyzing the cost on a square meter basis difficult. Keep in mind Tridipanel is extremely versatile construction system. For return on investment, the Tridipanels account for a fraction of the structure's cost. And the dinars that spent on it can be made up very quickly in energy savings alone. Over the life of the structure, the savings are quite staggering.

The Benefits of the Tridipanel System

1. Fast and high quality construction time saved- 50% faster than standard construction speedy occupancy - saves money on construction, reduces the need for heavy equipment on job and fewer trades on job site.
2. Strength, durability and greater structural integrity virtually maintenance-free wall system saves on long term replacement cost of structure polystyrene panel will not decay monolithic design for superior strength.
3. Safety and security excellent performance in seismic zones (earthquake resistance) non-combustible structure, and excellent high wind protection-up to 350 km/h. It is insect, termite, rodent resistant mold, mildew, and fungi resistant.
4. Pro environment and energy efficient maximum conservation of forestry products and offers value for generations and saves many earth resources dramatically reduces consumption of fossil fuels.
5. Quality, comfort and design flexibility virtually eliminate outdoor noises reduce drafts and wide temperature fluctuations enjoy air quality virtually free of dust, pollen and allergens with use of an air exchanger create an acoustical environment for full advantage of sophisticated sound systems.
6. Electrical and plumbing are through the interior side of the Tridipanel, so there are fewer wall penetrations, which keep thermal loss at a minimum, save 50% to 80% of heating and cooling costs, reduce size and cost of HVAC System, (Figure8).

Figure 8: The propane torch trims back the polystyrene foam cleanly and neatly for installation of rebar, plumbing installations, and electrical conduit [6].

THIRD SYSTEM: INTEGRATED BUILDING SYSTEM

Integrated Building System, Universal Building System or UrbanKit building system is the result of a life-long pursuit of knowledge and intellectual initiative by the Greek architect Dimitri Papanikolaou. Thorough his search for better buildings, Papanikolaou had come with number of good and creative ideas. His search though is grounded on his profound interest of the biological principles of design and the idea of economy which lies beneath any successful construction and resonates down to the level of its basic elements. As he likes to state, "successful construction confines excessive structure to a minimum"[7].

In the late 1970's and early 1980's he develops a system of prefabricated cubes cast with light concrete which can be combined in order for the windows and doors to be opened with cutting tools as needed. His goal is to minimize the amount of processed information. From the mid 1980's he creates a building system that consists of two basic elements, columns and slabs which are assembled with semi-elastic screwed nodes. This building system is called IBS (Integrated Building System). A variety of buildings with more than 100,000 square meters are constructed with this system. Office buildings like Intracom LTD'S headquarters enlargement and many housing projects are constructed in a short time and within their economic budgets Figure (9).

Figure 9: The first approach for a IBS panels, the prefabrication of entire cubes with lightconcrete and the assemblage of cubes into luxurious home [7].

The Idea Behind Integrated Building System

Integrated Building System (IBS) is a building system that can be fabricated in a highly automated environment which offers a constantly increasing level of security, quality and high precision engineering in a very affordable price range because they can be mass manufactured and distributed all over the world in great numbers. The significance of industrial building element prefabrication can be comprehended when viewed in light of the highly rationalized car production industry.

In the second half of the1990's Papanikolaou was ready to move his building system a significant leap forward in developing the Integrated Building System (IBS). He recognized due to his long experience in prefabrication that the problem of heavy concrete element transport was the key logistic problem which limited the delivery and market share of such structures to a few hundred kilometers.

He asked himself how he could transport only the information consistent to a building without transporting its mass. Is it possible to build urban structures with the efficiency cars are manufactured? As a result the UrbanKit building system was developed. An important project was the erection of the (AIA) (Athens International Airport) offices, housing the administration of the new Athens Airport at the time of its construction. The planning and construction of the 5000 m^2 facility was done in a period of three months Figure (10).

Figure 10: The 5000 m^2 administration office for (Athens International Airport) in Spata was planned and constructed in a period of 3 months [7].

The opportunity for further synthesis was given to Dimitri Papanikolaou with the architectural design competition for the conceptual proposal of the Olympic Village for the year 2004. The urban concept is based entirely on the UrbanKit structural skeleton and is organized in terms of multifunctional urban cells, which reduce the need for excessive transport fluctuation of urban functions.

The concept was honored with the first prize amongst three equal first prizes. In the development of the proposal important contribution came from Dr. of engineering architect Lefteris Virirakis and the Anaparastasis team. Mr. Virirakis conducts research on the field of application of genetic algorithms in architecture and he offered in the case of the Olympic Village his knowledge of how to streamline the design process in

accordance to bio-design rules. For all the above the proposal is more than just architectural morphology. It is the invention of the city as a living organism of biological imminence**.** It is sustainable city Figure (11).

The real potential of Integrated Building System becomes clear in the scale of the creation of autonomous, multifunctional urban cells that reduce operational cost of the city and project an opportunity for the reverse of the chaotic, cancer like expansion of conventional car dependent urban patterns, which deny the rules of biological template.

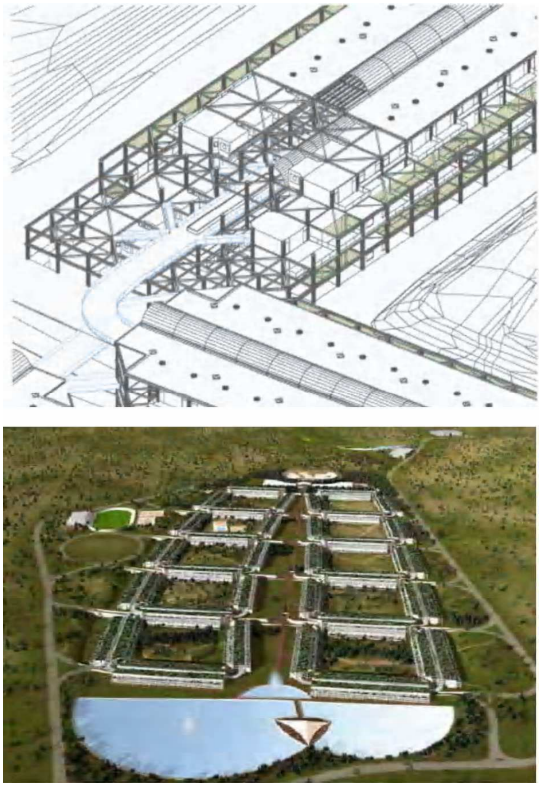

Figure 11: Olympic Village Athens, year 2004.

How Could Buildings Possibly Be Mass Produced and Distributed Anywhere in the World?

It is not easy to imagine a way to make the erection of building structures accessible to industrial methods. The weight per square meter of an average building is between one and two tones. Integrated Building System is giving a reasonable answer to this context of problems

- Integrated Building System solves the problem of transportation by solving the problem of weight. Conventional prefabrication transports 25 m^2 of built structure with every truckload. Integrated Building System transports 400 to 500 m^2 of built structure for every truck load Figure (12).

- It can be produced in an automated manufacturing environment and exported anywhere in the country or in the world.

Stages of Container Packaging

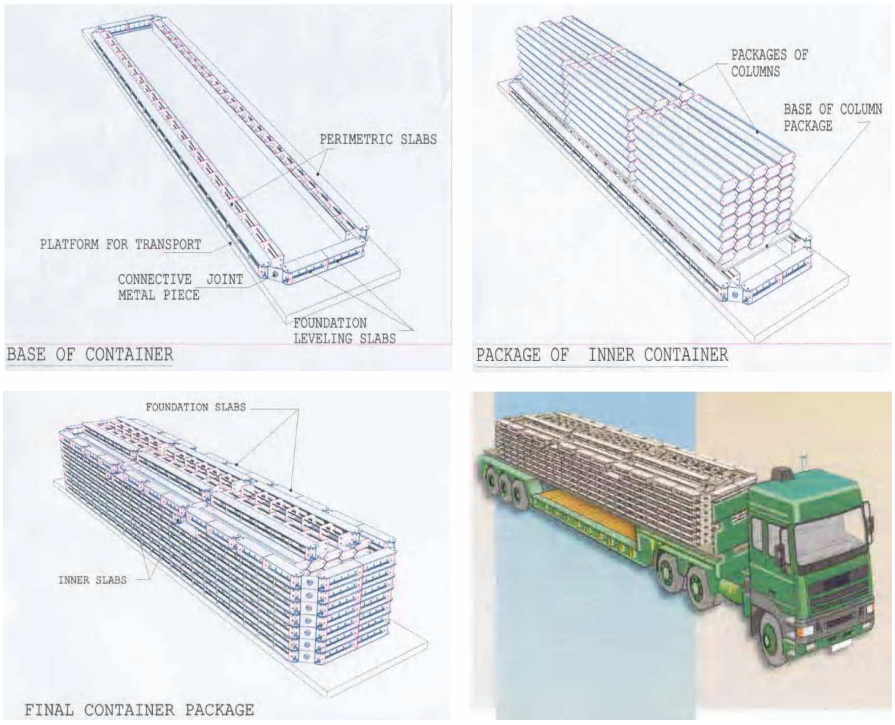

Figure 12: 500 sq.m. of structure are assembled from the elements of one container.

Stages of Structure Assembly

The construction idea is the creation of an industrially produced electro-mechanical skeleton. The structural elements contain the entire electromechanical information that is necessary for the composition of a built entity, so that from a given part (a column) the least possible structural volume will occur, which will in turn create a bigger unit, and all these units will be brought together in an autonomous functional urban cell. The repetition of this urban cell creates the settlement. In other words the idea copies biological techniques for the building of habitation, which is effectively a living biological construction itself.

As soon as the necessary trenches are dug up, the whole of an autonomous electromechanical skeleton is erected, which is industrially produced with extremely low errors. Within this skeleton areas of dry construction are created, covering all possible functional needs. The connection of the electro-mechanisms is done at any positions of the spatial grid.

Before the internal works are begun, access routes to the basements, the roads, the lifts, the stairs, the drainage, the insulation and the air-conditioning connections must all be completed Figure (13).

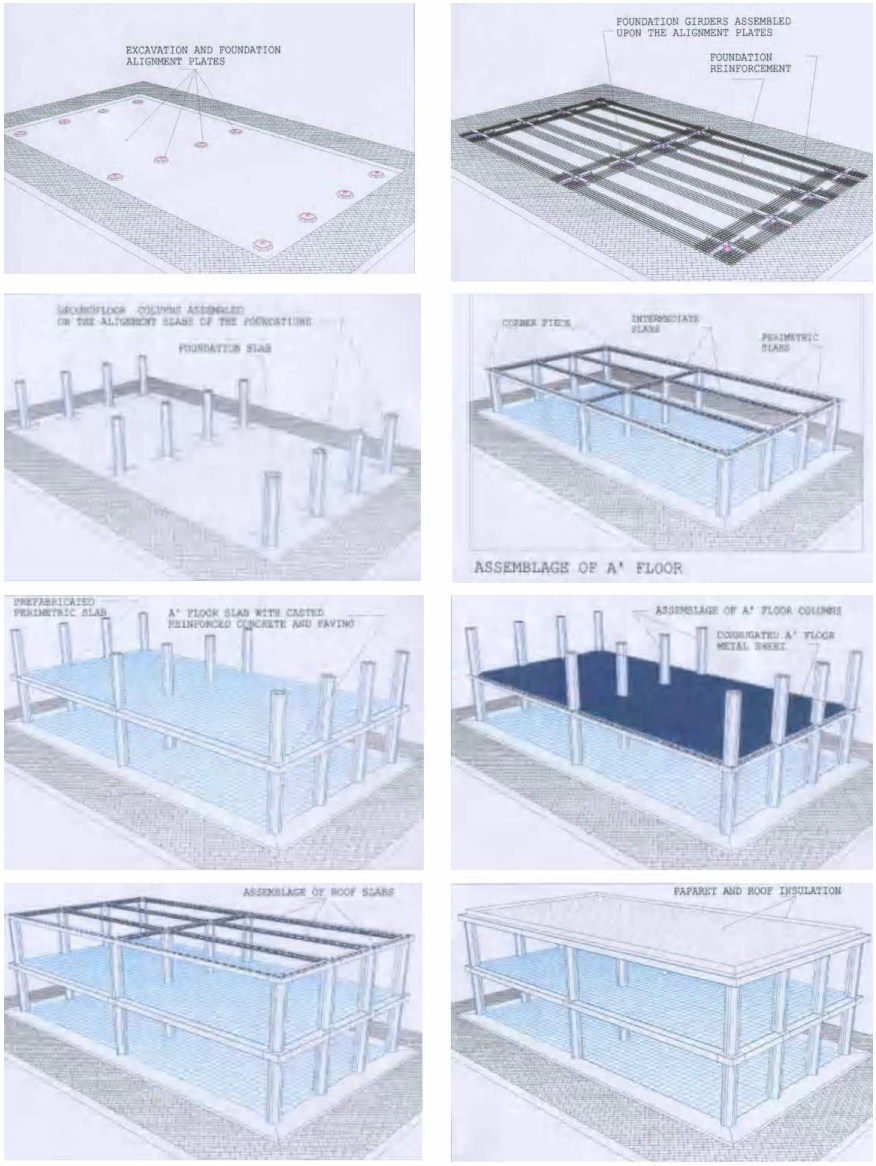

Figure 13: The construction idea is the creation of an industrially produced electro-mechanical skeleton [7].

The Electro-Mechanical Skeleton consists of a column to which beams can be screwed at either end Figure (14).

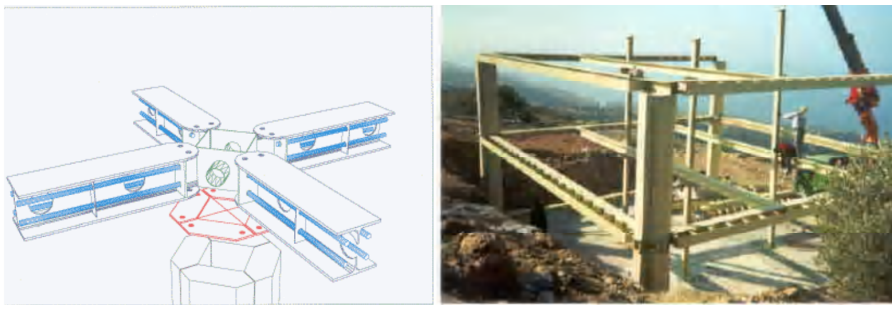

Figure 14: The semi-rigid Column-slab joint is unique to the (IBS) and offers exceptional structural performance due to its ductile and elastic behavior [7].

The column is produced by a centrifuge, leaving it hollow in the middle, for the electro mechanical arteries to pass through (drainage, ventilation, wiring, strong and weak currents, pipes, water transport system from the geothermal field).

Integrated building system creates urban structures that are:

1. At least 50% lighter than conventional constructions, and have excellent and proven earthquake performance.
2. Integrated Building System prefabricated elements are produced in highly automated industrial environment. It can be assembled and disassembled, due to semi-rigid screwed connections, which means that structures are reusable. This is a great contribution to the environment and the creation of sustainable urban structures.
3. The assembly of the building structure is easy and fast tracked. Unskilled workers with the help of a manual or a short introduction can quickly assemble the structure with normal market tools since all junctions are screwed. At the same time electromechanical installations and piping are integrated
4. Integrated Building System prefabricated elements can erect 500 m^2 of structure with a single container shipment which can be delivered anywhere in the country. Thus the mass of transport is dramatically decreased in comparison to conventional prefabrication methods where heavy precast elements have to be transported.
5. This technology can be exported efficiently anywhere in the world. High capital investment in automated manufacture is feasible, because the product can serve a global market just as car manufactures can.
6. The building elements can be reused when the built environment has to be altered, sometime in the future.

The core value of Integrated Building System, it can be fabricated in a highly automated environment. And the significance of industrial building element prefabrication can be comprehended when viewed in light of the highly rationalized car production industry.

Thus building of housing units and urban structures becomes significantly more efficient. The new innovative building system is an advanced prefabricated building system which combines criteria for biological design with the highly automated industrial fabrication of building elements and their transport anywhere in the world, in order to assemble urban structures. As a result, construction of housing projects becomes easy, fast and economic. It can be purchased one of standard houses or tailored one to suit particular project or to suit customer exact needs.

FINAL REMARKS

The following remarks highlight the major points discussed in this paper.

- The costs for the provision of sufficient number of houses to those in need represent a major investment item in the national budget. At the individual level also, building costs represent a high item in the family budget.
- Traditionally, the basic methodology of constructing concrete houses at different regions of the country without consideration of natural conditions has not changed over the last 40 years or so. This method of constructing is expensive, time consuming and not suitable to the southern region of Libya.
- Housing system works on the age of old simple principal that less is often more. Therefore, the systems listed above adapted the concept that less work is more satisfaction, without compromising the client freedom to change and place the internal walls in any configuration.
- The three systems provide alternative construction technologies that could be adopted to Libyan needs. They are sophisticated, efficient and cost effective.
- The study showed that, great reduction in the cost of construction up to 30% can be achieved using any of the three systems. The study also indicated that about 60% reduction in construction time could be achieved.
- The suggested systems produce the most economical and high quality product. They can be manufactured in one of standard houses or tailor one to suit a particular project or to tailor a product to suit customer exact needs.
- Furthermore the producers of the above building technologies can also be engaged to train customer's site crews in any country to ensure that the housing system is being utilized to its greatest efficiency. Since very minimal tools are required in the construction of this project it is of the greatest ease to construct anywhere in the world.
- It should also be noted that these systems are not suitable for one off supply. Large volumes are required to maintain an economical result.
- In general "Low cost affordable technology means inexpensive construction, superior quality and durable structures" [8].

REFERENCES

[1] Macsai, J. Holland,E. Nachman,H. Yacker, J. Housing, John Willey& Sons, New York, 1976, p. 4.

[2] Building Community with Straw Bales by Students of Penn State and the University of, http://www.corcon.com/lch/index.html Eco-Villa Low-Cost Housing, Washington, viewed June 2006.

[3] Camilleri, Peter. Low Cost Housing Prototypes Using Alternative Block Design, Mauritius Research Council, Sydney Australia, -brochure-.2003.

[4] Steel. J. Hassan Fathy, Academy Editions, St. Martin's press. London, 1988, p.25.
[5] http://www.aidomes.com American Ingenuity, INC. Holiday Springs Road, Rockledge, Florida.pdf, viewed December, 21, 2009.
[6] E.V.G. of RAABA, Hardrian Trid-System, Pdf. Sydney, Australia, 2009.
[7] http://www.urbankit.gr, The UrbanKit Greece/Athens, Pdf, viewed November, 12, 2005.
[8] http://www. Moladi.com, Moladi Building communities, low cost housing system, viewed August, 2009.