Seminar II

ROBOTIC RESEARCH INSTITUTE

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CHAPTER 01: Background of the project

1.1 Introduction
1.2 Project brief
1.3 Project Introduction
1.4 Aims and objectives of the project
1.5 Diagrammatic analysis
1.6 Given program
1.7 conclusion

1.1 Introduction:

This is the first chapter where a brief of the project is given along with a general idea about the site and its surroundings. A basic program obtained from the client is also presented and formal introduction to the project and its aims and objectives are clarified in this section of the writing.

1.2 Project brief:

Project Title: Robotics Research Institute

Site Location and Area: The site was chosen to be in Agargaon, in a site which has a proposal of Bangladesh Institute of Science and Technology, within a proposed Administrative Zone, according to the land use pattern of Dhaka city. The total area allocated for the project is 2.67 acre. The site is surrounded by administrative buildings like Islamic Foundation, Bangladesh Computer Council and Science Museum.

Client: Initiator of the project is Science and Technology Ministry with cooperative participation of Education Ministry under Vision2021 project, Government of Bangladesh and the implementing body is The Science and Technology Ministry in corporate with Education Ministry, Government of Bangladesh.

1.3 Project introduction:

Robotics is a branch of engineering that involves the conception, design, manufacture, and operation of robots. This field overlaps with electronics, computer science, artificial intelligence, mechatronics, nanotechnology and bioengineering.

In many developed countries around the world Robotics is introduced to the general people alongside restricted researches for military and national defense. Today robotics is a rapidly growing field, as the world continues to research, design and build new robots we lack a proper research center. Surveys and studies shows that it’s time for us to think about Robotics to keep up with the progressive world thus a need for Robotics Research Institute comes into the scenario.

1.4 Aims and objective of the project:

- To create a research based facility for the scientists and interested personals of this country and abroad as well.
- To create a center where general people can access and gain knowledge of the latest technology, can gets used to it and has a head start in the field of technology.
- To create a facility which is not hidden but open for all to an extent and at the same time a functional research zone as well.

1.5 Diagrammatic analysis:

Study about robotics and such technologies

Program Derivation

Site Study and Analysis

Analyzing Case Studies of Similar Typology

Concept Development from different Studies

Analyzing functional Spaces and other issues

Design Development in Different Phases

Chart 01: Diagrammatic analysis

1.6 Given program:

No.	**Functions**	
01.	Administration Block	
	• *Office Space* • *Conference Area*	
02.	Resource Block	
	• *Library & Archive* • *Multimedia Projection Room*	
03.	Academic Block	
	• *Studios* • *Research Laboratory* • *Workshops* • *Simulation Ground* • *Storage and Hanger*	
04.	Research Block	
	• *Research Laboratories* • *Workshops* • *Simulation Ground* • *Storage and Hanger*	
05.	Civic Functions	
	• *Exhibition Space* • *Café*	

Chart 02: Given program

1.7 Conclusion:

From this chapter a basic idea of the site as well as the project can be achieved. Later parts of the writing will have elaboration of these topics discussed in details.

CHAPTER 02: Site appraisal

2.1 Introduction:

Site appraisal chapter holds the details of the site such as site location, area, and its surroundings. The access ways or streets and communication means, landmarks. An overall idea of the site is achieved from this chapter. Analysis of the site and its surroundings is presented here.

2.2 Site location:

Fig 01: Site location (Source Google earth)

The site is located at the city center, so that people from different levels can easily access into an interactive robotics research facility. Since researchers from different nations are suppose to research in such a facility it's preferable to put it in a site which is not isolated and inaccessible. Even though in most of the cases a research facility of such use is kept secluded and out of peoples reach I believe that a human machine interactive platform will create acceptance for newer inventions as well as the knowledge of latest technologies can appear in front of mass people on time. Thus keeping in mind that a proper research facility backed by other related institutions and administrations as well as a place that people can easily access the site was chosen to be in Agargaon, in a site which has a proposal for Bangladesh Institute of Science and Technology and the area is an Administrative Zone in accordance to the proposed land use pattern of Dhaka city.

2.2.1 Site communication and traffic:

Fig 02: Site communication way (Source modified Google earth)

- The site is located in such a position that it is readily accessible from all the directions and the site has thoroughfare on East West and South of it.
- There is no vehicular restriction in any of the roads and the site can easily be accessed via public transportation system.
- The site is within an administrative zone and initially master planned by Luis I. Khan.
- The site can be accessed from any part of Dhaka city easily to its South is Dhanmondi, to North is Mirpur and to West is Lalmatia.
- The major node nearest to the site (north-eastern to the site) is created by the diversion road and Begum Rokeya Sharani with Syed Mahbub Morshed Avenue.

2.2.2 Landmarks and important administrative buildings:

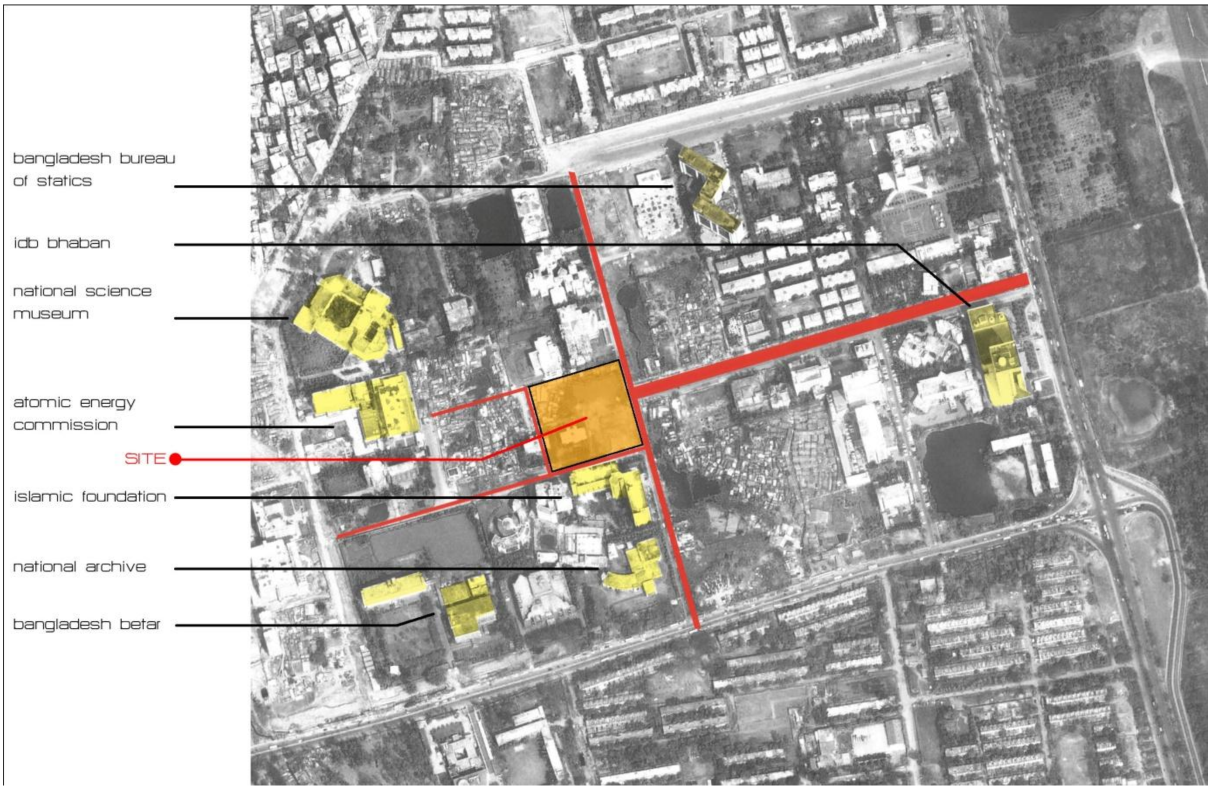


Fig 03: Important administrative buildings or landmarks (Source modified Google earth)

- The site is surrounded by several important structures and administrative buildings
- There are several public buildings such as National Archive Building, National Science Museum etc.
- Several administrative buildings such as Islamic Foundation Building, LGED office, Bureau of Statics Building etc surround the site.
- However there is only on active public place which is the largest computer market, BCS computer city also known as IDB Bhaban.
- There are several hospitals, institutions and other mixed use buildings as well.

2.3 Site analysis:

The site is under DPZ 10 and WARD 41. The site is supposed to be an administrative zone although the current land use pattern shows a mixture of administrative buildings and institutions. The institutions like science museum, paramanu bhaban, computer council, archeology department, national archive etc involves the penetration of people into this zone although the force of function is purely administrative in nature.

2.3.1 Flood prone area:

This is a low lying area and it goes under water (max. 3 feet) during the monsoon due to lack of proper water drainage system. The nearest water body is Kallyanpur damn.

2.3.2 Green areas:

The proposed land use pattern shows that the old airport will be replaced as the only green for the area. Although the surroundings have moderate amount of greenery and the existing

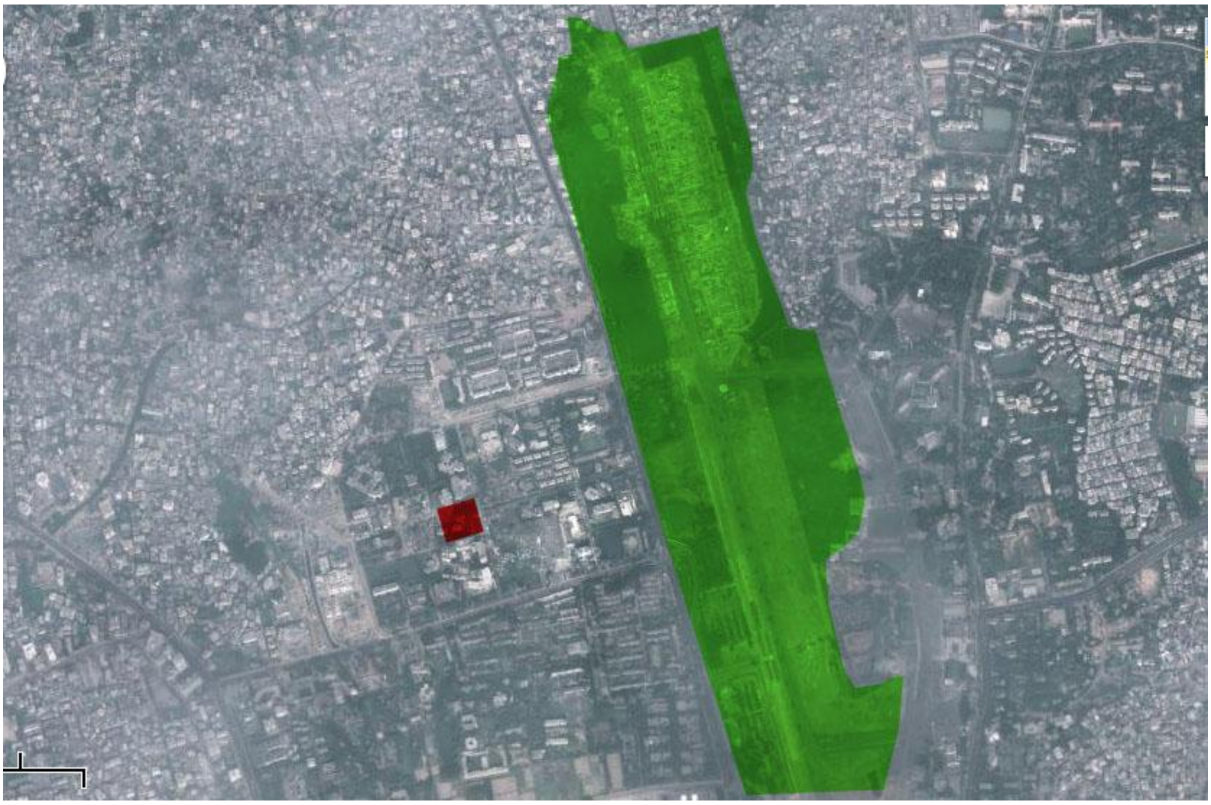


Fig 04: Green area (old airport proposed) [Source modified Google earth]

Infrastructures have kept sufficient amount of green on their respective sites. The surrounding vacant plots are now green and there are several old trees to the west of the site the adjacent plot.

2.3.3 Temperature:

Season	Month	Maximum (Degree C)	Minimum (Degree C)
Dry-Summer	March- June	40	35
Monsoon	July- October	30	32
Winter	Nov- Feb	26	28

Chart 03: Temperature Chart of Agargaon [Source: http://weather.mirbig.net/en/BD/81/1349452_Agargaon]

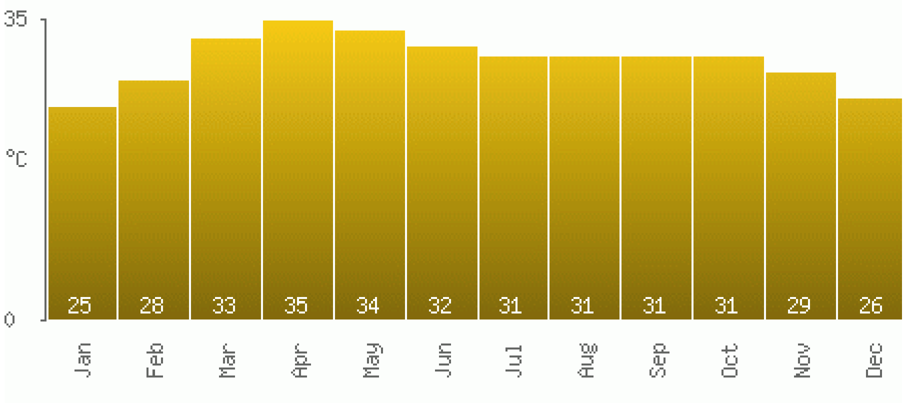


Chart 04: Temperature Chart of Agargaon [Source: http://weather.mirbig.net/en/BD/81/1349452_Agargaon]

2.3.4 Rainfall:

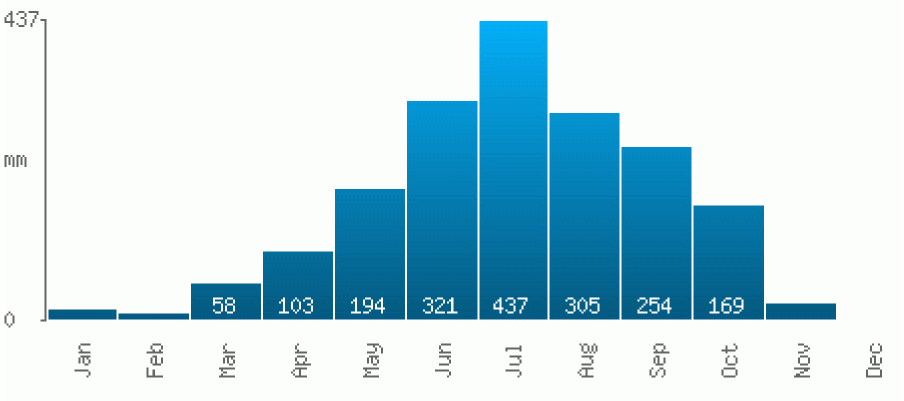


Chart 05: Temperature Chart of Agargaon [Source: http://weather.mirbig.net/en/BD/81/1349452_Agargaon]

2.3.5 Noise:

As the site is way far from the main roads the site and surroundings are quiet and noise generation from surrounding buildings are not taken into consideration since these are all public administration buildings and no such heavy noise is generated from these buildings.

2.4 Site surroundings:

Fig 05: Site surroundings panorama of site and Islamic foundation building (Source: Shabab, 15.05.2012)

Fig 06: Site surroundings national science museum and LGED building (Source: Shabab, 15.05.2012)

Fig 07: Site surroundings national science museum and LGED building (Source: Shabab, 15.05.2012)

Fig 08: panorama of site (Source: Google earth)

Fig 09: road on the west and east existing situation of site (Source: : Shabab, 15.05.2012)

Fig 10: idb bhaban and computer commission. (Shabab, 15.05.2012)

2.5 SWOT analysis:

Strength:

- The zoning and surrounding functions create an internal zone of education, administration and public gathering.
- The site has 150 feet proposed street on the East and 100 feet proposed street on the South.
- The site is permeable and easily accessible.
- Since the zone is an administrative sector of the city it lacks proper public space, the site can be a potential public gathering space if it's designed in such a way.

Weakness:

- The site is more into an administrative zone which does not invite people from all sectors.
- The site does not have any inherit character of its own and is crowded by several other administrative buildings.

Opportunities:

- There is no topographic constrain.
- The proposed and use pattern and proposed streets make this site appropriate for any further expansion.
- Science museum and Liberation war museum will draw public attraction furthermore.

Threats:

- The area is unorganized and all the developments are scattered.
- The area is planned as the administrative sector of the city but spontaneous growth makes it an unplanned administrative zone with no public space and green space.

2.6 Conclusion:

After consideration, the design would be influenced by the forces of the site. It has to merge with its surroundings. The fabrication and materials would reflect the dwelling and the nature of the site.

CHAPTER 03: Literature review

3.1 Introduction

3.2 What is robotics

3.2.1 Components of robotic system

3.2.2 Robotics and interaction with the physical world

3.2.3 Scales in robotic system

3.2.4 Background sensitivity

3.2.5 Types of robot

3.3 Responsive architecture

3.4 Tensegrity architecture

3.4.1 Basic tensegrity modules

3.4.2 The benefits of tensegrity structure

3.5 Actuated tensegrity structure

3.5.1 Shape changing mechanism

3.5.2 Actuation

3.6 Conclusion

3.1 Introduction:

The study focuses on issues like robotis, its aesthetics and mechanism. Key concept of what robotics is? The types of robots and their application in different sector. Responsive architecture and kinetic forms are studied thoroughly. A basic idea is projected how actuation is possible for structures and their implementation.

3.2 What is robotics:

Robots are man-made mechanical devices that can move by themselves, whose motion must be modeled, planned, sensed, actuated and controlled, and whose motion behavior can be influenced by "programming". Robots are called "intelligent" if they succeed in moving in safe interaction with an unstructured environment, while autonomously achieving their specified tasks.

This definition implies that a device can only be called a "robot" if it contains a movable mechanism, influenced by sensing, planning, actuation and control components. It does not imply that a minimum number of these components must be implemented in software, or be changeable by the "consumer" who uses the device; for example, the motion behavior can have been hard-wired into the device by the manufacturer.

So, the presented definition, as well as the rest of the material in this article, covers not just "pure" robotics or only "intelligent" robots, but rather the somewhat broader domain of **robotics and automation**. This includes "dumb" robots such as: metal and woodworking machines, "intelligent" washing machines, dish washers and pool cleaning robots, etc. These examples all have sensing, planning and control, but often not in individually separated components. For example, the sensing and planning behavior of the pool cleaning robot have been integrated into the mechanical design of the device, by the intelligence of the human developer.

Robotics is, to a very large extent, all about system integration, achieving a task by an actuated mechanical device, via an "intelligent" integration of components, many of which it shares with other domains, such as systems and control, computer science, character animation, machine design, computer vision, artificial intelligence, cognitive science, biomechanics, etc. In addition, the boundaries of robotics cannot be clearly defined, since also its “core” ideas, concepts and algorithms are being applied in an ever increasing number of “external” applications, and, vice versa, core technology from other domains (vision, biology, cognitive science or biomechanics, for example) are becoming crucial components in more and more modern robotic systems.

3.2.1 Components of robotic systems:

This figure depicts the components that are part of all robotic systems. The purpose of this Section is to describe the semantics of the terminology used to classify the chapters in the article: “sensing”, “planning”, “modeling”, “control”, etc.

The real robot is some mechanical device (“mechanism”) that moves around in the environment, and, in doing so, physically interacts with this environment. This interaction involves the exchange of physical energy, in some form or another. Both the robot mechanism and the environment can be the “cause” of the physical interaction through **“Actuation”**, or experience the “effect” of the interaction, which can be measured through **“Sensing”**.

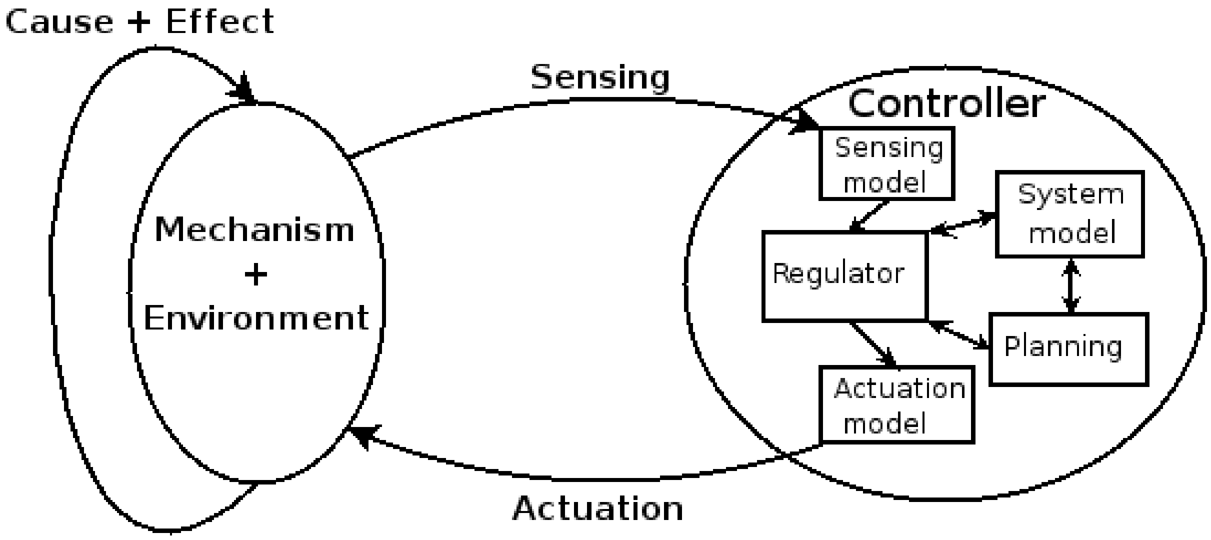


Fig 11: Flow diagram of robotic mechanism [http://www.electronicsteacher.com/robotics/what-is-robotics.php]

3.2.2 Robotics and interaction with the physical world:

Sensing and actuation are the physical ports through which the “Controller” of the robot determines the interaction of its mechanical body with the physical world. As mentioned already before, the controller can, in one extreme, consist of software only, but in the other extreme everything can also be implemented in hardware.

Within the Controller component, several sub-activities are often identified:

Modeling: The input-output relationships of all control components can (but need not) be derived from information that is stored in a model. This model can have many forms: analytical formulas, empirical look-up tables, fuzzy rules, neural networks, etc.

The name “model” often gives rise to heated discussions among different research “schools”, and the article is not interested in taking a stance in this debate: within the article, “model” is to be understood with its minimal semantics: “any information that is used to determine or influence the input-output relationships of components in the Controller.”

The other components discussed below can all have models inside. A “System model” can be used to tie multiple components together, but it is clear that not all robots use a System model. The “Sensing model” and “Actuation model” contain the information with which to transform raw physical data into task-dependent information for the controller, and vice versa.

Planning: This is the activity that predicts the outcome of potential actions, and selects the “best” one. Almost by definition, planning can only be done on the basis of some sort of model.

Regulation: This component processes the outputs of the sensing and planning components, to generate an actuation set point. Again, this regulation activity could or could not rely on some sort of (system) model.

The term “control” is often used instead of “regulation”, but it is impossible to clearly identify the domains that use one term or the other. The meaning used in the article will be clear from the context.

3.2.3 Scales in robotic systems:

The above-mentioned “components” description of a robotic system is to be complemented by a “scale” description, i.e., the following system scales have a large influence on the specific content of the planning, sensing, modeling and control components at one particular scale, and hence also on the corresponding sections of the article.

Mechanical scale: The physical volume of the robot determines to a large extent the limits of what can be done with it. Roughly speaking, a **large-scale** robot (such as an autonomous container crane or a space shuttle) has different capabilities and control problems than a **macro** robot (such as an industrial robot arm), a **desktop** robot (such as those “sumo” robots popular with hobbyists), or **milli micro** or **nano** robots.

Spatial scale: There are large differences between robots that act in 1D, 2D, 3D, or 6D (three positions and three orientations).

Time scale: There are large differences between robots that must react within hours, seconds, milliseconds, or microseconds.

Power density scale: A robot must be actuated in order to move, but actuators need space as well as energy, so the ratio between both determines some capabilities of the robot.

System complexity scale: The complexity of a robot system increases with the **number of interactions** between independent sub-systems, and the control components must adapt to this complexity.

Computational complexity scale: Robot controllers are inevitably running on real-world computing hardware, so they are constrained by the available **number of computations**, the available **communication bandwidth**, and the available **memory storage**.

Obviously, these scale parameters never apply completely independently to the same system. For example, a system that must react at microseconds time scale cannot be of macro mechanical scale or involve a high number of communication interactions with subsystems.

3.2.4 Background sensitivity:

Finally, no description of even scientific material is ever fully objective or context-free, in the sense that it is very difficult for contributors to the article to “forget” their background when writing their contribution. In this respect, robotics has, roughly speaking, two faces: (i) the mathematical and engineering face, which is quite “standardized” in the sense that a large consensus exists about the tools and theories to use (“systems theory”), and (ii) the AI face, which is rather poorly standardized, not because of a lack of interest or research efforts, but because of the inherent complexity of “intelligent behavior.” The terminology and systems-thinking of both backgrounds are significantly different, hence the article will accommodate sections on the same material but written from various perspectives. This is not a “bug”, but a **“feature”**: having the different views in the context of the same article can only lead to a better mutual understanding and respect.

Research in engineering robotics follows the bottom-up approach: existing and working systems are extended and made more versatile. Research in artificial intelligence robotics is top-down: assuming that a set of low-level primitives is available, how could one apply them in order to increase the “intelligence” of a system. The border between both approaches shifts continuously, as more and more “intelligence” is cast into algorithmic, system-theoretic form. For example, the response of a robot to sensor input was considered “intelligent behavior” in the late seventies and even early eighties. Hence, it belonged to A.I. Later it was shown that many sensor-based tasks such as surface following or visual tracking could be formulated as control problems with algorithmic solutions. From then on, they did not belong to A.I. any more.

3.2.5 Types of robots:

Nowadays, robots do a lot of different tasks in many fields and the number of jobs entrusted to robots is growing steadily. That's why in my opinion one of the best ways how to divide robots into types is a division by their application. There are:

Industrial robots - Industrial robots are robots used in an industrial manufacturing environment. Usually these are articulated arms specifically developed for such applications as welding, material handling, painting and others. If we judge purely by application this type could also include some automated guided vehicles and other robots.

Domestic or household robots - Robots used at home. This type of robots includes many quite different devices such as robotic vacuum cleaners, robotic pool cleaners, sweepers, gutter cleaners and other robots that can do different chores. Also, some surveillance and telepresence robots could be regarded as household robots if used in that environment.

Medical robots: Robots used in medicine and medical institutions. First and foremost surgery robots. Also, some automated guided vehicles and maybe lifting aides.

Service robots: Robots that don’t fall into other types by usage. These could be different data gathering robots, robots made to show off technologies, robots used for research, etc.

Military robots: Robots used in military. This type of robots includes bomb disposal robots, different transportation robots, reconnaissance drones. Often robots initially created for military purposes can be used in law enforcement, search and rescue and other related fields.

Entertainment robots: These are robots used for entertainment. This is a very broad category. It starts with toy robots such as robosapien or the running alarm clock and ends with real heavyweights such as articulated robot arms used as motion simulators.

Space robots : I’d like to single out robots used in space as a separate type. This type would include robots used on the International Space Station, Canadarm that was used in Shuttles, as well as Mars rovers and other robots used in space.

Hobby and competition robots: Robots that you create. Line followers, sumo-bots, robots made just for fun and robots made for competition.

Now, as you can see there are examples that fit into more than one of these types. For example, there can be a deep sea exploration robot that can gather some valuable information that can be used for military purposes.

Also, I have seen that a division into two types is used, accordingly - industrial and service robots. However, I cannot see how a Mars exploration rover fits into one of these general types. Therefore I have used "service robots" in a narrower manner. In my version a term "service robots" serves as "others". This is basically a type where robots that don't fit into other types should fall in.

3.3 Responsive architecture:

Responsive architecture is an evolving field of architectural practice and research. Responsive architectures are those that measure actual environmental conditions (via sensors) to enable buildings to adapt their form, shape, color or character responsively (via actuators).

Responsive architectures aim to refine and extend the discipline of architecture by improving the energy performance of buildings with responsive technologies (sensors / control systems / actuators) while also producing buildings that reflect the technological and cultural conditions of our time.

Responsive architectures distinguish themselves from other forms of interactive design by incorporating intelligent and responsive technologies into the core elements of a building's fabric. For example: by incorporating responsive technologies into the structural systems of buildings architects have the ability to tie the shape of a building directly to its environment. This enables architects to reconsider the way they design and construct space while striving to advance the discipline rather than applying patchworks of intelligent technologies to an existing vision of "building".

The common definition of responsive architecture, as described by many authors, is a class of architecture or building that demonstrates an ability to alter its form, to continually reflect the environmental conditions that surround it.

The term "responsive architecture" was given to us by Nicholas Negroponte, who first conceived of it during the late nineteen sixties when spatial design problems were being explored by applying cybernetics to architecture. Negroponte proposes that responsive architecture is the natural product of the integration of computing power into built spaces and structures, and that better performing, more rational buildings are the result. Negroponte also extends this mixture to include the concepts of recognition, intention, contextual variation, and meaning into computing and its successful (ubiquitous) integration into architecture. This cross-fertilization of ideas lasted for about eight years. Several important theories resulted from these efforts, but today Nicholas Negroponte’s contributions are the most obvious to architecture. His work moved the field of architecture in a technical, functional, and actuated direction.

Since Negroponte’s contribution, new works of responsive architecture have also emerged, but as aesthetic creations rather than functional ones.

Finally an account of the development of the use of responsive systems and their history in respect to recent architectural theory can be found in Tristan d'Estree Sterk's recent opening keynote address (ACADIA 2009) entitled "Thoughts for Gen X— Speculating about the Rise of Continuous Measurement in Architecture".

3.4 Tensegrity structure:

Tensegrity structures are structures based on the combination of a few simple but subtle and deep design patterns:

- loading members only in pure compression or pure tension, meaning the structure will only fail if the cables yield or the rods buckle
- preload or tensional pre-stress, which allows cables to be rigid in tension
- mechanical stability, which allows the members to remain in tension/compression as stress on the structure increases

Because of these patterns, no structural member experiences a bending moment. This can produce exceptionally rigid structures for their mass and for the cross section of the components.

A conceptual building block of tensegrity is seen in the 1951 Skylon tower. Six cables, three at each end, hold the tower in position. We say the three cables connected to the bottom "define" its location. The other three cables are simply keeping it vertical.

A three-rod tensegrity structure (shown) builds on this: the ends of each rod look like the bottom of the Skylon tower. As long as the angle between any two cables is smaller than 180°, the position of the rod is well defined. There are also three connection points defining the position the rod tops. This makes the overall structure stable. Variations such as Needle Tower involve more than three cables meeting at the end of a rod, but these can be thought of as three cables defining the position of that rod end with the additional cables simply attached to that well-defined point in space.

Eleanor Hartley points out visual transparency as an important aesthetic quality of these structures. Korkmaz et al. put forward that the concept of tensegrity is suitable for adaptive architecture thanks to lightweight characteristics.

3.4.1 Basic tensegrity modules:

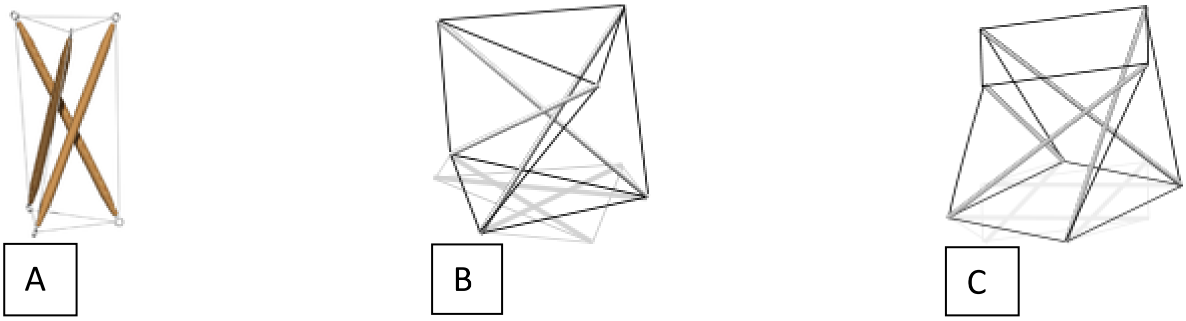


Fig 12: Basic tensegrity modules [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]

A. The simplest tensegrity structure (a 3-prism)
B. Another 3-prism
C. A similar structure but with four compression members

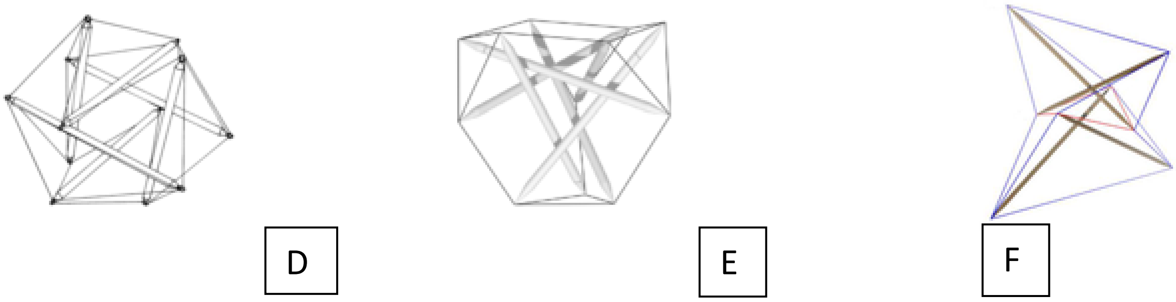


Fig 13: Basic tensegrity modules [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]

D. Tensegrity Icosahedrons, Buckminster Fuller, 1949
E. Tensegrity Tetrahedron, Francesco della Salla, 1952
F. Tensegrity X-Module Tetrahedron, Kenneth Snelson, 1959

3.4.2 The Benefits of tensegrity structure:

A large amount of literature on the geometry, art form, and architectural appeal of tensegrity structures exists, but there is little on the dynamics and mechanics of these structures. From finding results for simple symmetric structures appear and show an array of stable tensegrity units is connected to yield a large stable system, which can be deployable. Tensegrity structures for civil engineering purposes have been built and described. Several reasons are given below why tensegrity structures should receive new attention from mathematicians and engineers, even though the concepts are 50 years old.

Tension stabilizes:

A compressive member loses stiffness as it is loaded, whereas tensile member gains stiffness as it is loaded. Stiffness is lost in two ways in a compressive member. In the absence of any bending moments in the axially loaded members, the forces act exactly through the mass center, the material spreads, increasing the diameter of the center cross section; whereas the tensile member reduces its cross-section under load. In the presence of bending moments due to offsets in the line of force application and the center of mass, the bar becomes softer due to the bending motion. For most materials, the tensile strength of a longitudinal member is larger than its buckling (compressive) strength. (Obviously, sand, masonry, and unreinforced concrete are exceptions to this rule.) Hence, a large stiffness-to-mass ratio can be achieved by increasing the use of tensile members.

Tensegrity structures are efficient:

It has been known since the middle of the 20th century that continua cannot explain the strength of materials. The geometry of material layout is critical to strength at all scales, from nanoscale biological systems to megascale civil structures. Traditionally, humans have conceived and built structures in rectilinear fashion. Civil structures tend to be made with orthogonal beams, plates, and columns. Orthogonal members are also used in aircraft wings with longerons and spars. However, evidence suggests that this “orthogonal” architecture does not usually yield the minimal mass design for a given set of stiffness properties. Bendsoe and Kikuchi, Jarre and others have shown that the optimal distribution of mass for 8 specific stiffness objectives tends to be neither a solid mass of material with a fixed external geometry, nor material laid out in orthogonal components. Material is needed only in the essential load paths, not the orthogonal paths of traditional manmade structures. Tensegrity structures use longitudinal members arranged in very unusual (and no orthogonal) patterns to achieve strength with small mass. Another way in which tensegrity systems become mass efficient is with self-similar constructions replacing one tensegrity member by yet another tensegrity structure.

Tensegrity structures are deployable:

Materials of high strength tend to have a very limited displacement capability. Such piezoelectric materials are capable of only a small displacement and "smart" structures using sensors and actuators have only a small displacement capability. Because the compressive members of tensegrity structures are either disjoint or connected with ball joints, large displacement, deployability, and stowage in a compact volume will be immediate virtues of tensegrity structures. This feature offers operational and portability advantages. A portable bridge, or a power transmission tower made as a tensegrity structure could be manufactured in the factory, stowed on a truck or helicopter in a small volume, transported to the construction site, and deployed using only winches for erection through cable tension. Erectable temporary shelters could be manufactured, transported, and deployed in a similar manner. Deployable structures in space (complex mechanical structures combined with active control technology) can save launch costs by reducing the mass required, or by eliminating the requirement for assembly by humans. The same deployment technique can also make small adjustments for fine tuning of the loaded structures, or adjustment of a damaged structure. Structures that are designed to allow tuning will be an important feature of next generation mechanical structures, including civil engineering structures.

Tensegrity structures can be more reliably modeled:

All members of a tensegrity structure are axially loaded. Perhaps the most promising scientific feature of tensegrity structures is that while the global structure bends with external static loads, none of the individual members of the tensegrity structure experience bending moments. (In this chapter, we design all compressive members to experience loads well below their Euler buckling loads.) Generally, members that experience deformation in two or three dimensions are much harder to model than members that experience deformation in only one dimension. The Euler buckling load of a compressive member is from a bending instability calculation, and it is known in practice to be very unreliable. That is, the actual buckling load measured from the test data has a larger variation and is not as predictable as the tensile strength. Hence, increased use of tensile members is expected to yield more robust models and more efficient structures. More reliable models can be expected for axially loaded members compared to models for members in bending.

Tensegrity structures facilitate high precision control:

Structures that can be more precisely modeled can be more precisely controlled. Hence, tensegrity structures might open the door to quantum leaps in the precision of controlled structures. The architecture (geometry) dictates the mathematical properties and, hence, these mathematical results easily scale from the nanoscale to the megascale, from applications in microsurgery to antennas, to aircraft wings, and to robotic manipulators.

3.5 Actuated tensegrity structure:

With the introduction of parametric modeling to architectural design, it has become possible to alter the design throughout the design process. The importance, or exact values, of the parameters can be considered until the last stages of design. The final design is not unveiled until the values of all parameters are established. Although the use of parametric modeling has brought great advantages with regard to the adaptability of architectural design, these advantages are restrained to the design stage of a project. Once the design is finished and the building is constructed, changes in parametrical conditions can no longer be incorporated. Parametric models are typically tuned towards environmental conditions, which in turn usually vary over time. For a physical structure to reflect the full potential of parametric modeling, the behavior of the digital model would ideally be incorporated in the physical structure. A static structure would always be a compromised representation of the model. The result would be a responsive architecture that adjusts its properties as the parameters change. In this respect, responsive architecture is a means to extend the advantages of parametric design beyond the design stage. New findings and beliefs, changing environmental conditions, can be implemented in the completed building.

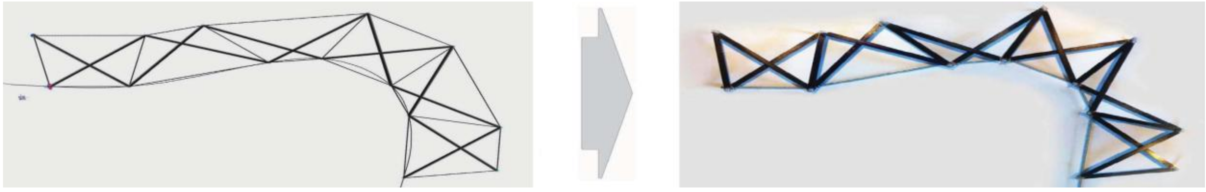


Fig 14: Actuation of the tensegrity structure [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]

3.5.1 Shape changing mechanism:

The curvature of (single curved) tensegrity systems can be controlled by changing the shape of the individual modules; more specifically by controlling the top-/ bottom width ratio of a row of modules perpendicular to the curvature . As the ratio rises the surface bends down and vice versa, where a ratio of 1 represents a planar surface. The width of the modules is controlled by changing the lengths of the cables/trusses. The simplest way to achieve the desired module deformation is by changing the top- and bottom cables parallel to the curvature while the other members of the module remain constant in length.

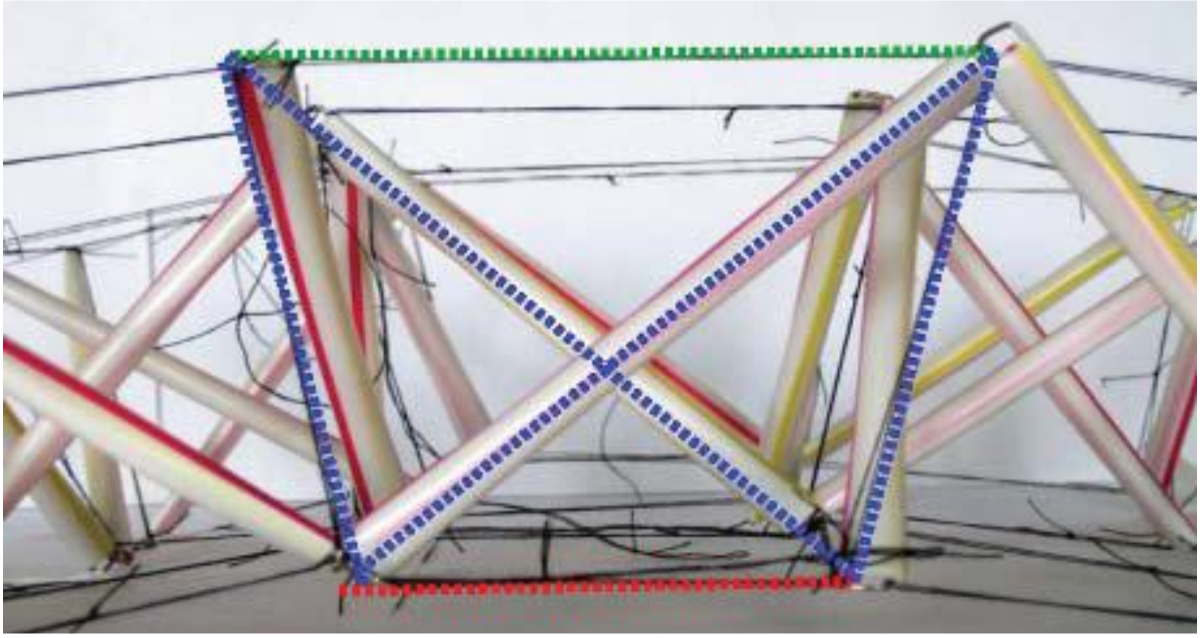


Fig 15: Expansion of structure [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]

Curvature of a tensegrity grid is changed by altering the length of the top and bottom cables of a row of modules. The curving behavior of a tensegrity grid subject to these length changes was studied and captured in a “2d” model as shown in the two top photographs of figure 8. The behavior was then translated into a parametric model that simulates this behavior. The digital model was made using the parametrical design tool Generative Components. The logic of this model is illustrated in figure 7, the positions of the joints are determined by the intersections of the circles which represent the lengths of the members. Figure 8 shows the physical and digital model of the mechanical principle utilized to control the curvature of the tensegrity system in various positions.

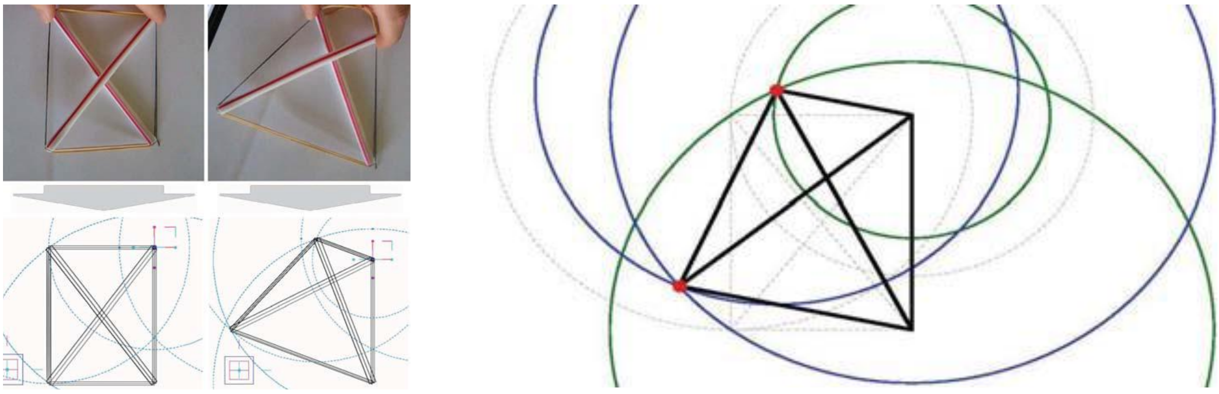


Fig 16: Modular deformation [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]

When a number of the modules described in the last section are linked and a dependency is created between the modules and a b-spline curve, the shape of the modules is automatically optimized to follow any given curve. The chain of modules is now controlled by the same parameters that define the curve. A model with these dependencies is shown in figure 9. To be certain that this 2d model accurately simulates the behavior of a (3d) tensegrity structure the model was then modified to a 3d situation.

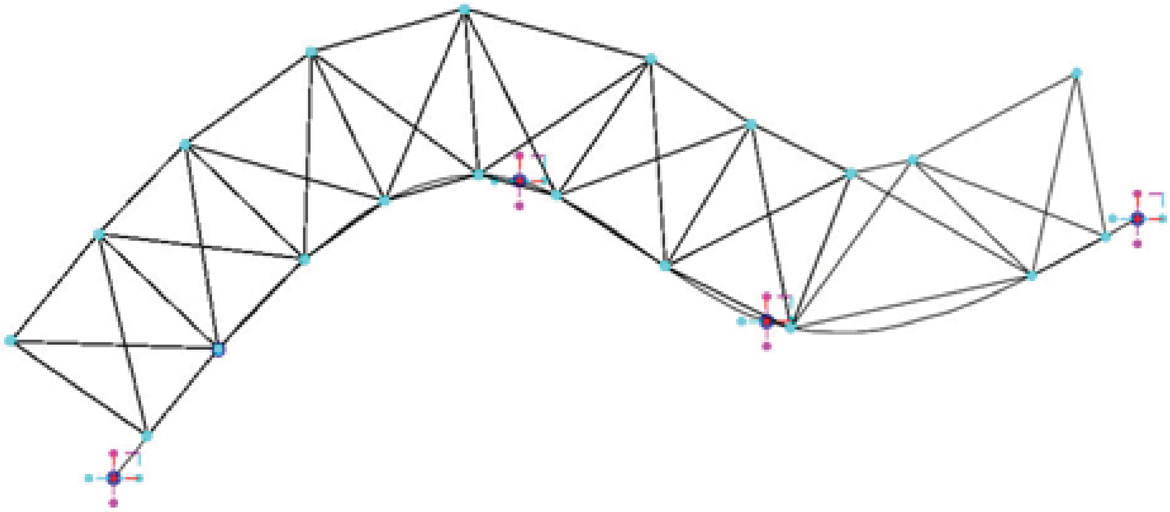
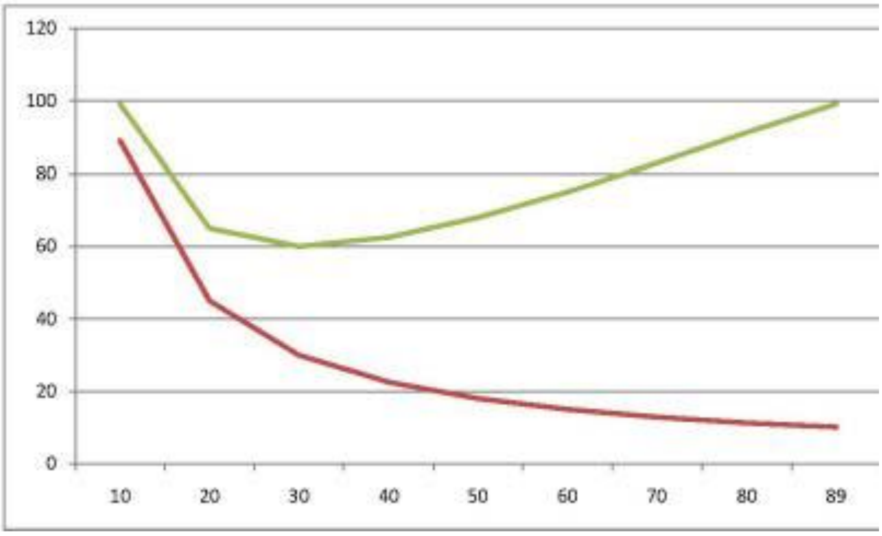


Fig 17: Tension points [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]

3.5.2 Actuation:

A crucial element in a responsive structure is the actuation mechanism. As mentioned before, the advantage of single curved surfaces is the possibility of synchronized activation of a row of modules perpendicular to the curvature. An important aspect to address with the design of a suitable actuator is the relationship between the lengths of the top/bottom cables of a row of modules. The relationship between these lengths is given by: b=n2/t

Fig 18: tensegraph [Synchronized Activation of Single-curved Tensegrity Grids for Responsive Architecture.pdf]



Where:

- b =length of bottom cable
- t =length of the top cable
- n =length of top or bottom in neutral position
- (when b=t)

A graphic representation of this relationship is given in figure 14. Digital synchronization could be realized by a configuration with several actuators in which the top cables are all of synchronized length, and the bottom cables are all b=n2/t. This type of actuator would however need a large number of actuators and would be very vulnerable to actuator defects. Mechanical synchronization driven by one single parameter for all cables, both top and bottom, would be much simpler and not vulnerable to any failure caused by inaccuracies or defects in the different actuators. For these reasons it was opted to design an actuator based on mechanical synchronization. The actuation principle that was designed controls the shape of an entire row of models by one single parameter. The relationship between the top and bottom cables is remained at b=n2/t by a mechanism with a corresponding relation between the top and bottom lengths

3.6 conclusions:

From this chapter an idea of robotics and actuated tensegrity structure is achieved. The through study makes clear of the fact that actuation is possible for structures and thus can reduce energy consumed.

CHAPTER 04: Literature review

4.1 Introduction

4.2 Center de pompidou

4.3 Tübitak Marmara Research Center

4.4 Caltech cahill center

4.5 Analysis and findings

4.1 Introduction:

Case studies of similar projects in terms of structure and tensegrity structures are presented here. The projects are related in times of design development and influences are depicted into the project.

4.2 Center de pompidou :

Architect: Renzo Piano, Richard Rogers
Location: Paris

The Centre Pompidou is a gigantic, futuristic arts center located in the Beaubourg {boh-boor'} district of Paris. President Georges Pompidou conceived (in 1969) the idea for Beaubourg, as the centre is also known, to bring art and culture to the "man in the street". It was completed in 1978 by the architects Renzo Piano of Italy and Richard Rogers of England, and by the engineering firm of Ove Arup and Partners of England. The structure forms a huge transparent box whose exposed frame of tubular steel columns carries trusses spanning the width of the building. External mechanical systems -- elevators painted red; escalators in clear plastic tunnels; and giant tubes for air (painted blue), water (green), and electricity (yellow) -- all are conspicuously placed on the outside of the main columns.

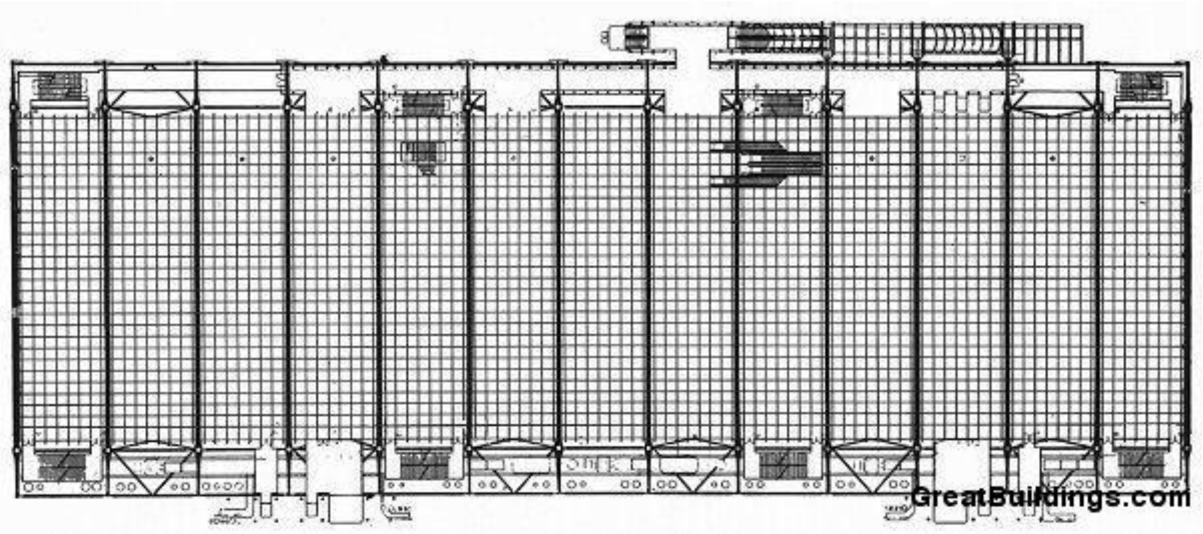


Fig 19: plan [Archdaily]

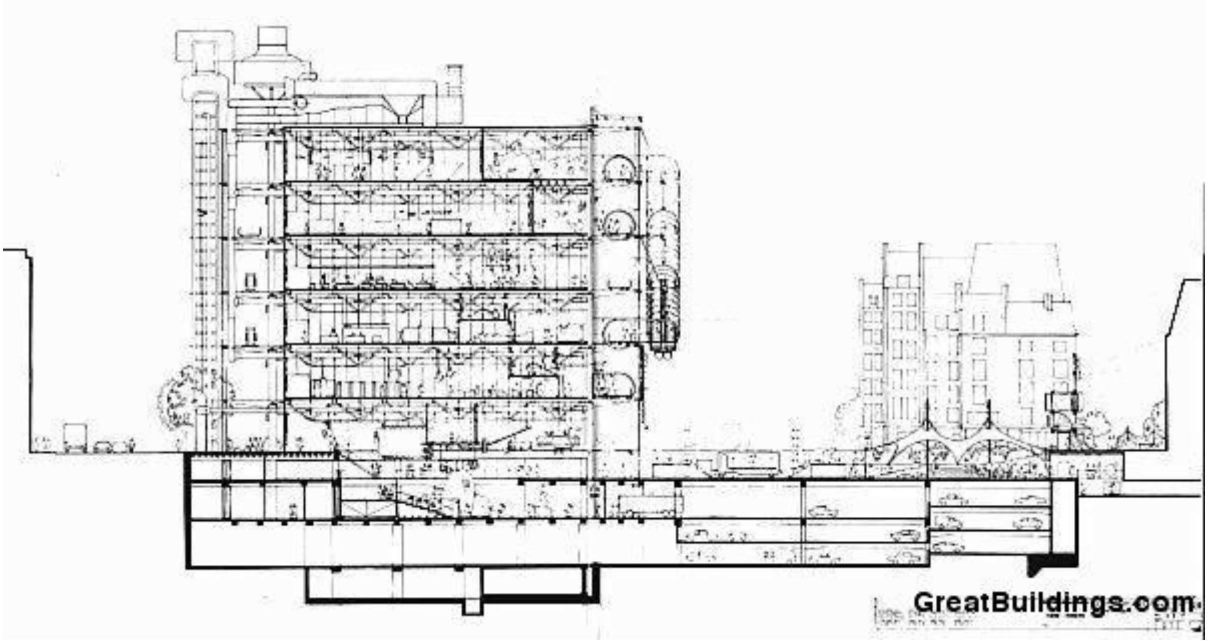


Fig 20: section [Archdaily]

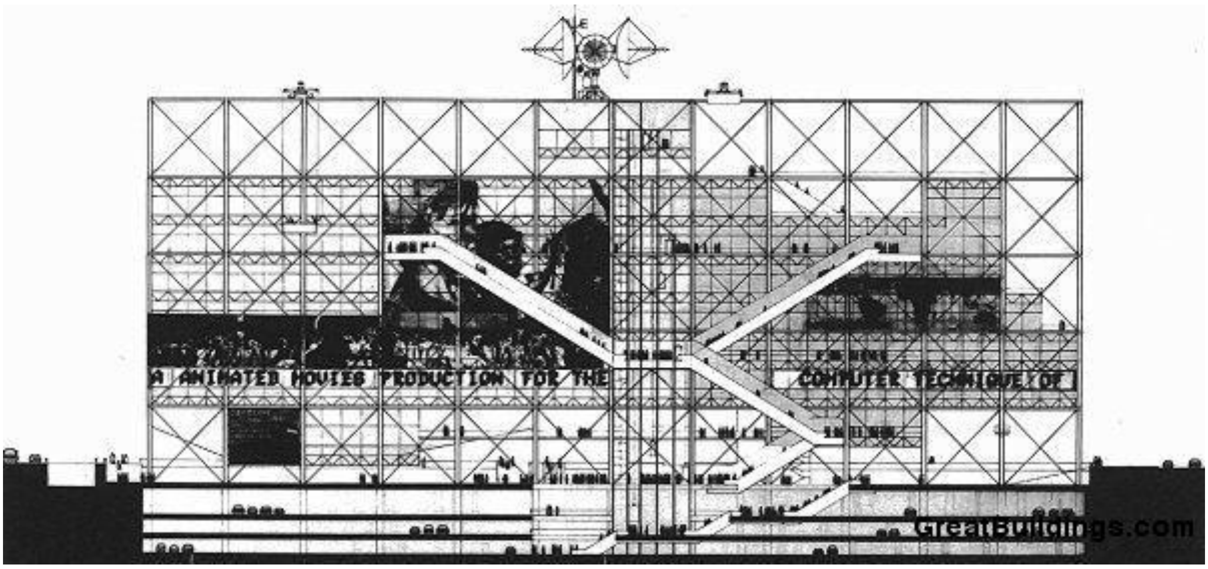


Fig 21: elevationn [Archdaily]

4.3 Tübitak Marmara Research Center:

Architect: **Architect(s) :** Erginoglu and Calislar Architects
Location: Gebze-Kocaeli , ISTANBUL - Turkey

Designed as the research and development headquarters of Turkcell, a private telecommunication company, the structure is located on the outskirts of Istanbul in the Tübitak Marmara Research Center Technology Free-Trade Zone. Taking the site context, views and orientation into consideration, the building offers a single-storey entry, rising to four storeys on the office side. The higher side of the structure is comprised of office spaces and the areas overlooking the land receive light from the large space created from the roof down. Hence, the office spaces get natural light from all four sides. The structure emerges from the ground like a “slice of cheese” and, with its grass roof, allows the employees to take advantage of a recreational space. Owing to the fact that it is conceived as an IT and technological production center accommodating 500 employees around the clock, the building features highest technological standards. Hence, it encompasses resting and sleeping areas as well as showers, a fitness center, a climbing wall and a billiard room. The right wing of the building houses meeting and seminar rooms, whereas the left wing includes the fitness center and recreational areas.

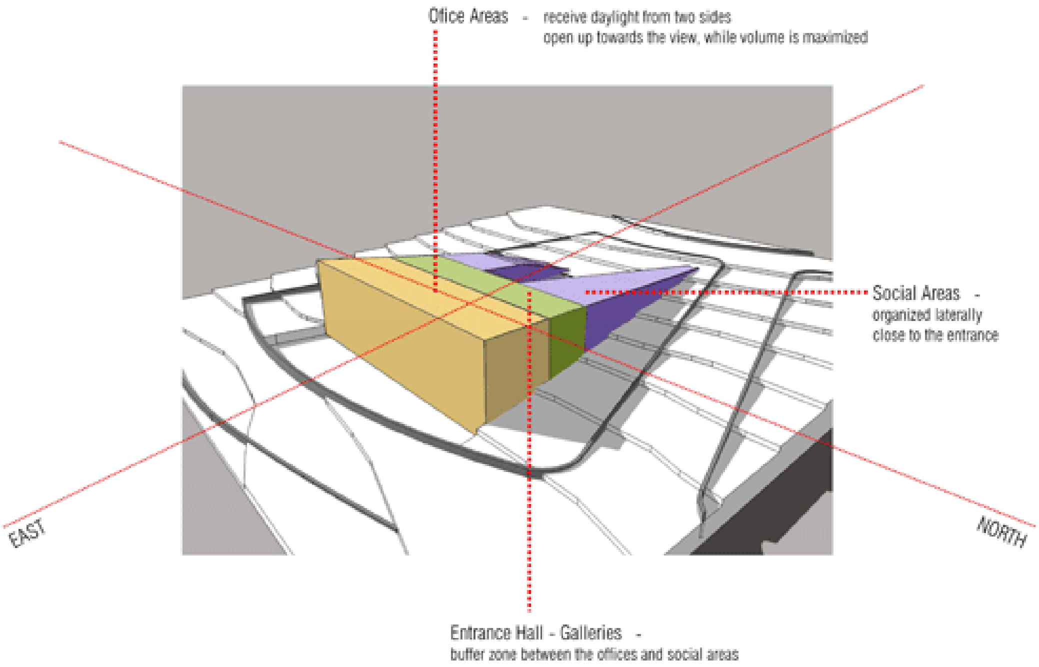


Fig 22: zoning 3D [Archdaily]

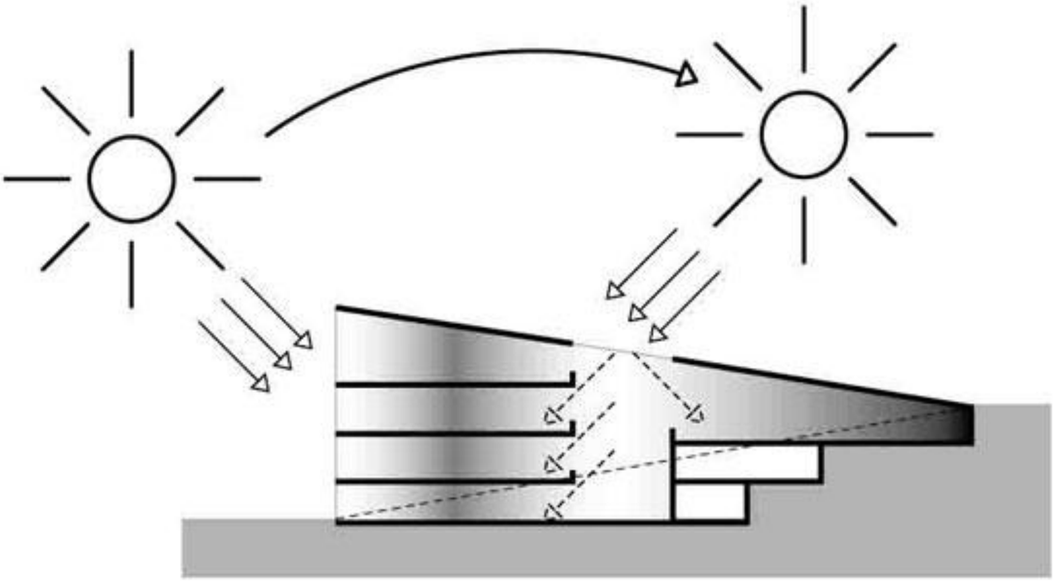


Fig 23: schematic section [Archdaily]

Fig 24: front elevation n rear view [Archdaily]

4.4 Caltech cahill center:

Architect: Morphosis Architects
Location: California, United States of America

The Cahill Center for Astronomy and Astrophysics brings together a dozen different groups into a single structure designed to facilitate collaboration and spontaneous discourse. In the tradition of ancient and modern architectural observatories found around the world, the building itself acts as an astronomical instrument. A vertical volume pierces the building, tilting its lens to admit light from the skies. The result is an occupiable telescope, a public space that links earth and sky even as it strives to link person to person. Elsewhere, force lines track the movement of light through the building so that as one moves through the space, formal fragments coalesce to reconstruct the interactions among light, architectural elements, and bodies as physical traces of the institution’s new ideas.

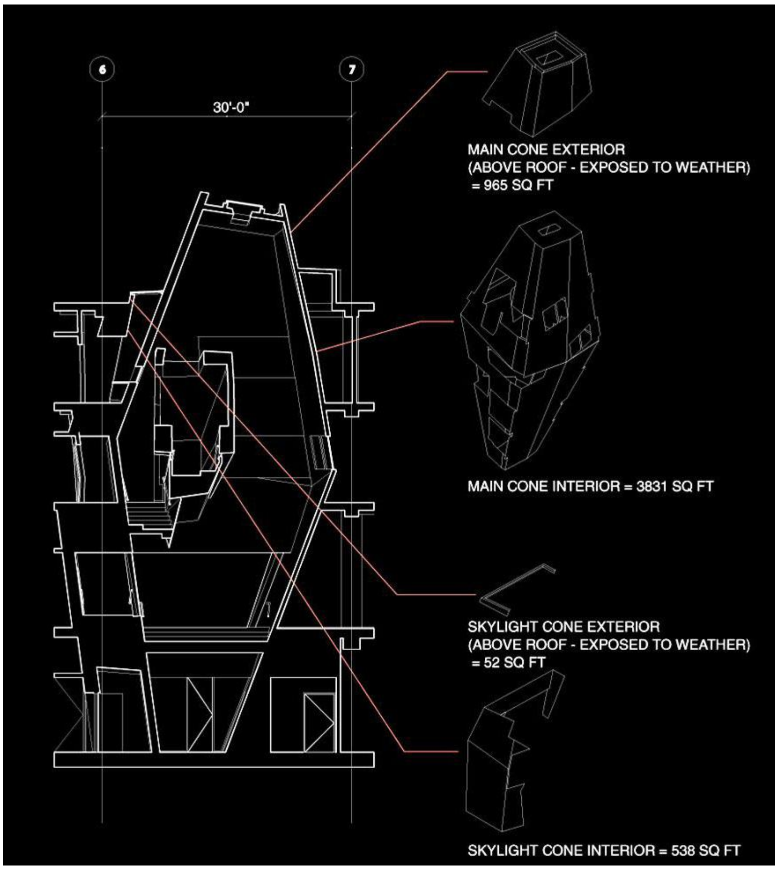


Fig 25: section and details [Archdaily]

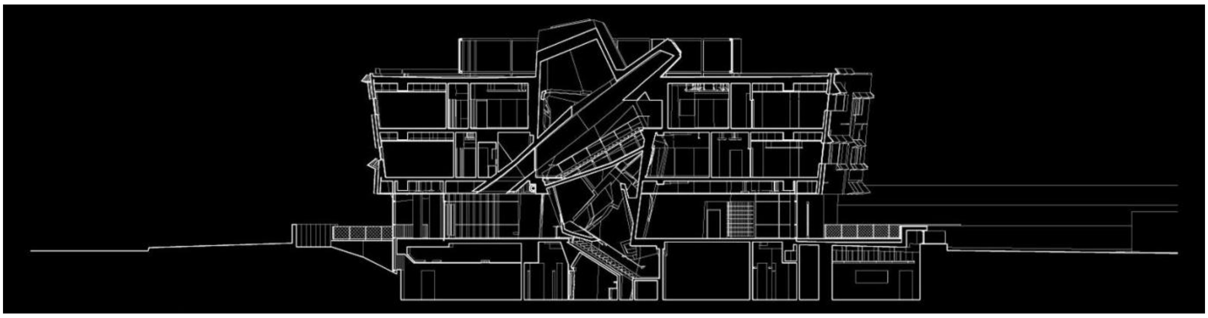


Fig 26: section [Archdaily]

Fig: 27: façade view [Archdaily]

4.5 Analysis and findings:

From the projects mentioned here various aspects are taken into account like structural system, façade treatment, zoning pattern and volumetric study of functional space. The projects are all unique and different as for their respective characters like exposed structure and undulated façade or volumetric zoning process.

CHAPTER 05: Program development

5.1 Introduction

5.2 Detail program

5.3 Conclusion

5.1 Introduction:

In this chapter an analysis of functional flow and their respective space requirement is discussed in brief. A final program with specified square feet space is presented.

5.2 detail program:

Robotics Research Institute

I. Administrative Block

a. Entry & Lobby		_2000	
b. Office space		_5500	
c. Conference area		_7000	
d. Prayer space		_2500	
e. Wash Room/Toilet		_1500	
30% circulation	_5550		
GRAND TOTAL			_24050 sq.ft

II. Resource Block

a. Entry & Lobby		_500	
b. Library & Archive		_7000	
c. Multimedia & Projection Area		_2000	
d. Server & Network room		_5500	
e. 30% circulation	_4500		
GRAND TOTAL			_**19500** sq.ft

III. Academic studio & Research Block

a. Studio		_4500	
b. Storage & Mechanical room		_1500	
c. 30% circulation	_1800		
GRAND TOTAL			_**7800** sq.ft

IV. Laboratory & Research Facility

a. Automation laboratory		_6000	
b. Mechanization laboratory		_6000	
c. Robotics laboratory		_10000	
d. Hanger & storage		_4000	
e. Conference & Common Room		_6500	
f. Supportive Facility		_2000	
g. 30% circulation	_10350		
GRAND TOTAL			_**46850** sq.ft

V. Human-Machine Interactive Zone

a. Entry & Lounge	_2000
b. Simulation ground & Exhibition Space	_35000
c. Restaurant & Cafe	_5000
d. 30% circulation	_12600
GRAND TOTAL	_**54600** sq.ft
TOTAL AREA	_**152800** sq.ft

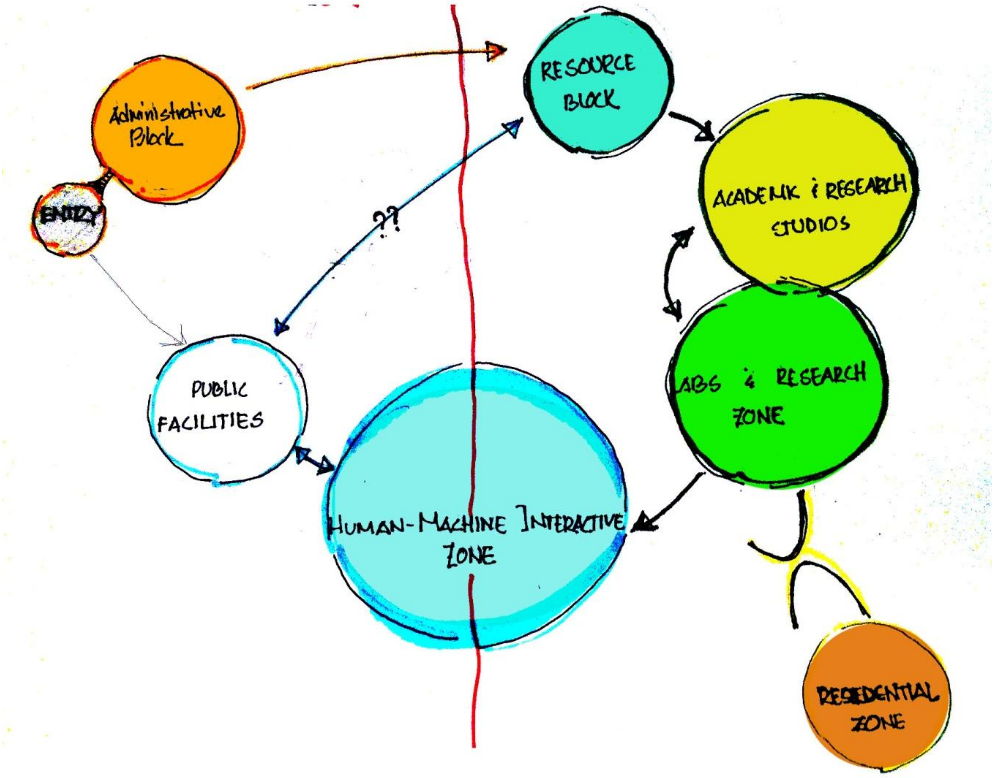


Fig 28: Flow Diagram [shabab, 2012]

5.3 Conclusion:

An idea of the program is achieved through various analysis and study of relevant projects. A flow diagram is obtained by studying the relation between public and private functions.

CHAPTER 06: Idea generation and design development

6.1 Introduction

6.2 Idea generation

6.3 Concept development

6.4 Form generation

6.5 Shell generation

6.6 Design development

6.1 Introduction:

This chapter contains the discussion of idea generation and concept development through several phases. The transformation of ideas and concept into design elements are clarified in this chapter. At its end the final proposal is added by the follow-up of total design phases and developments throughout the semester.

6.2 Idea generation:

The whole idea of the project is based on an interactive space for the mass people. From the very beginning my idea corresponded to an academic building and an open plaza, where general people can interact with robots and the building mass would be a display for the visitors not able to access it directly from the plaza but see everything that’s being done inside.

Through study of robotics aesthetics and its mechanism helped me derive the notion of exposed and shelled functional zones in robotics.

The mechanism is quite simple for any basic functioning robot. A robot senses its surroundings via sensors and takes appropriate measures on basis of complex calculation.

Hence the design was guided by factors of aesthetics and mechanism of dynamics which resulted into a different structural system for the institutional mass and an introduction of actuated or kinetic tensegrity shell structure.

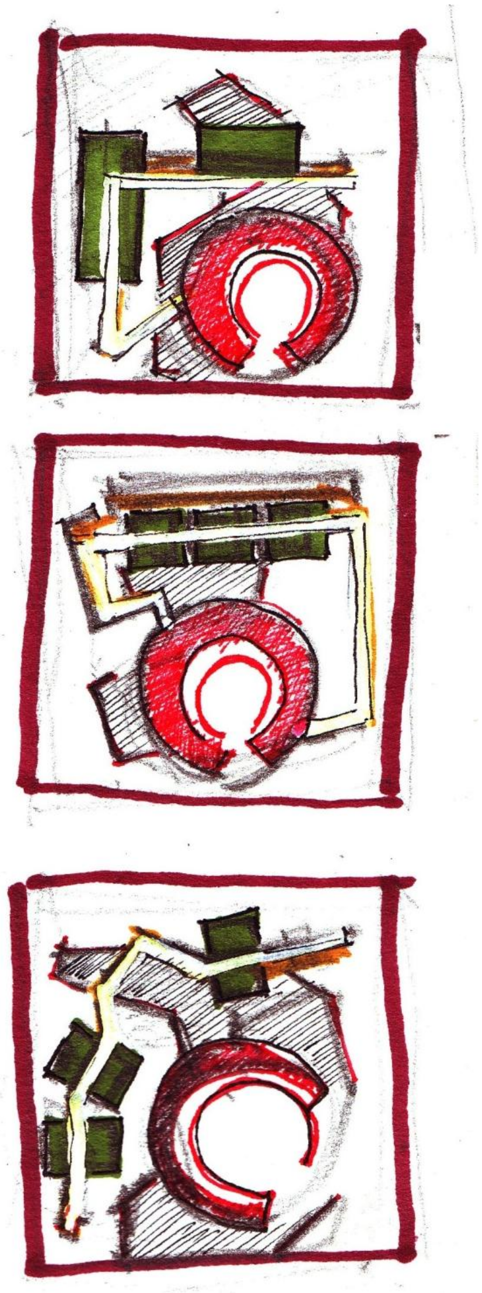


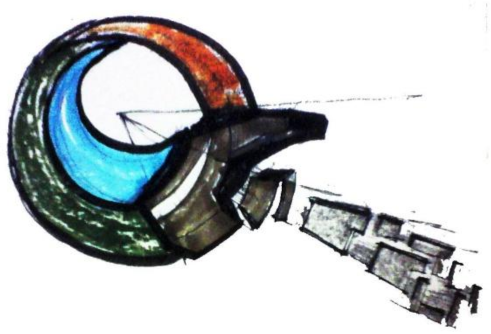
Fig 29: form and idea generation [shabab, 2012]

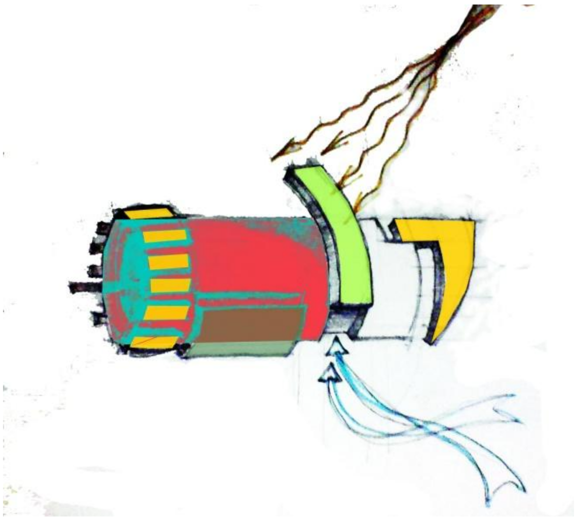
6.3 Concept development:

The whole idea is to generate motion or dynamic space. The design thus reflects motion in its formal expression although it's mostly static yet a sense of suspended animation grasps the mind as we see the project.

A force that tends to move out in forms or the play of blocks cutting out of the mother form and coming out into space and suspended in space is the major concept.

Finally the concept was to create a machine like institution where things would move around to create new space or shade an expose circulation.





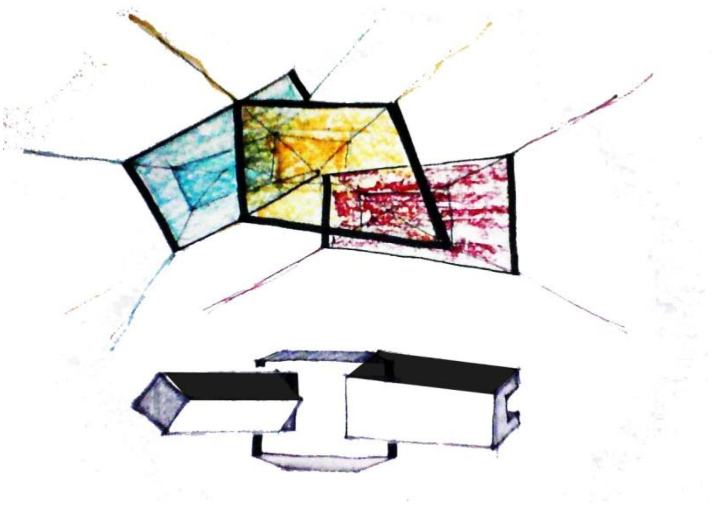


Fig 30: conceptual sketches [shabab, 2012]

6.4 Form generation:

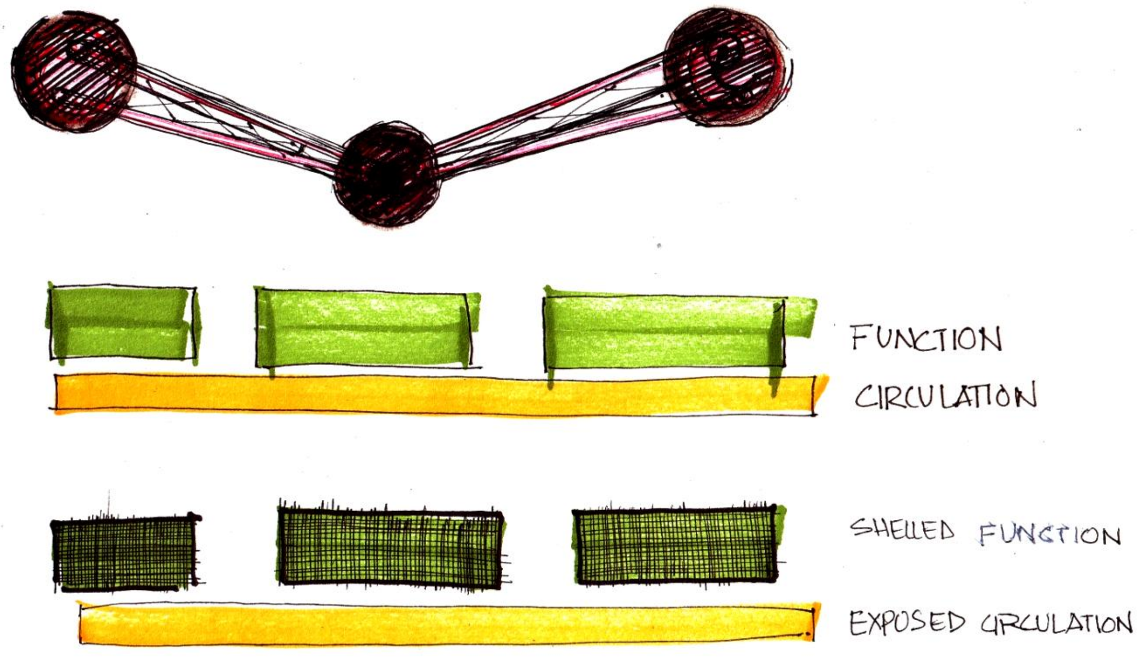


Fig 31: form generation [shabab, 2012]

Finally the idea was transformed into the design and an exposed structural system was introduced to support the exposed circulation of the institution mass. The plaza which is the core center of the project is proposed to be an actuated tensegrity shell that will act as a multipurpose interactive space.

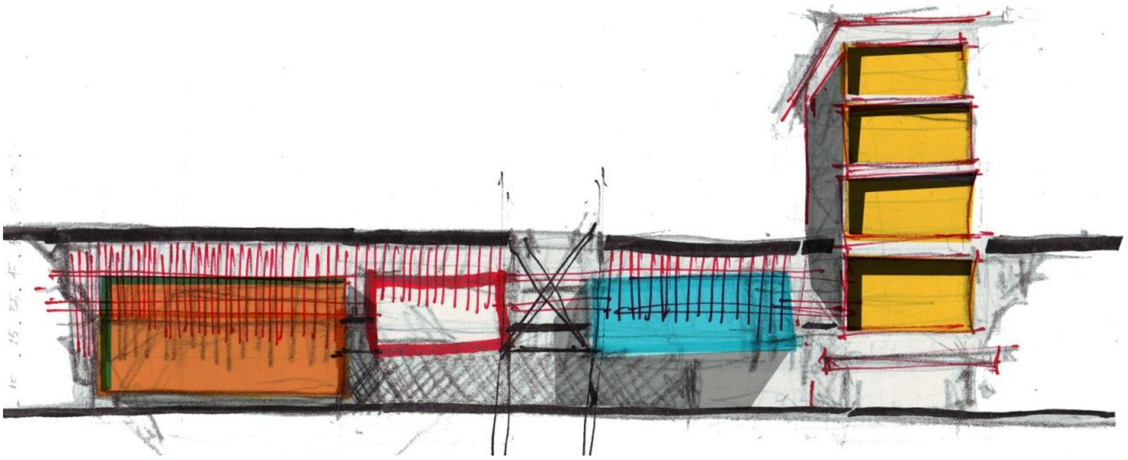


Fig 32: conceptual section [shabab,2012]

6.5 Shell generation:

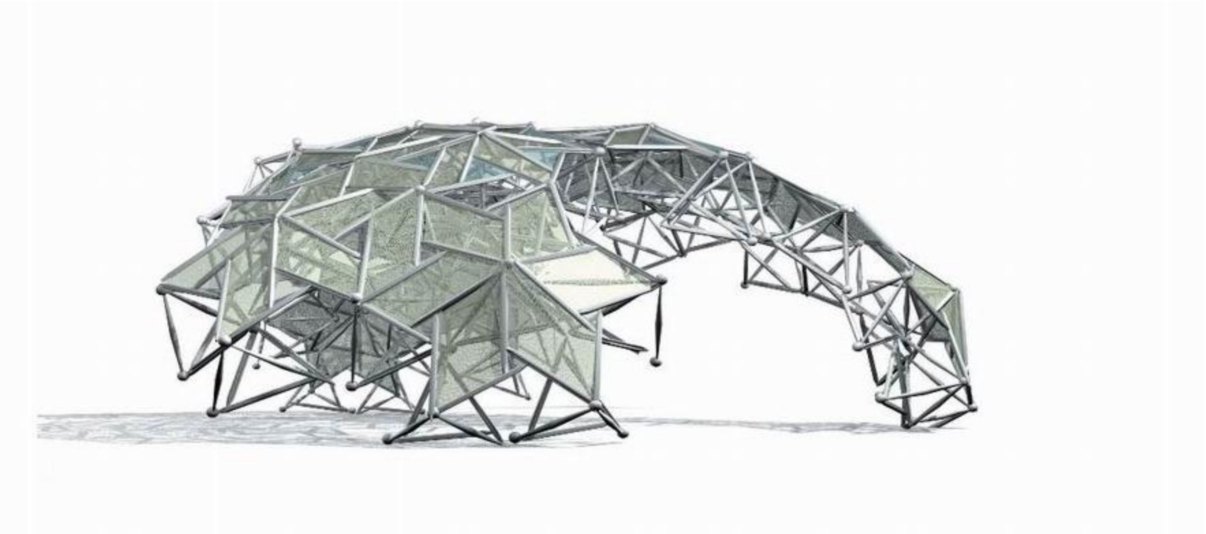


Fig 33: Tensegrity shell [shabab, 2012]

The basic idea of the shell is to show a movement on the basis of its analysis of environment and the occupants. Factors like heat cold air and other parameters are calculated on regular intervals to give a constant motion thus changing the shape of the shell. This is thus known as responsive architecture as it responds to its surrounding and the users.

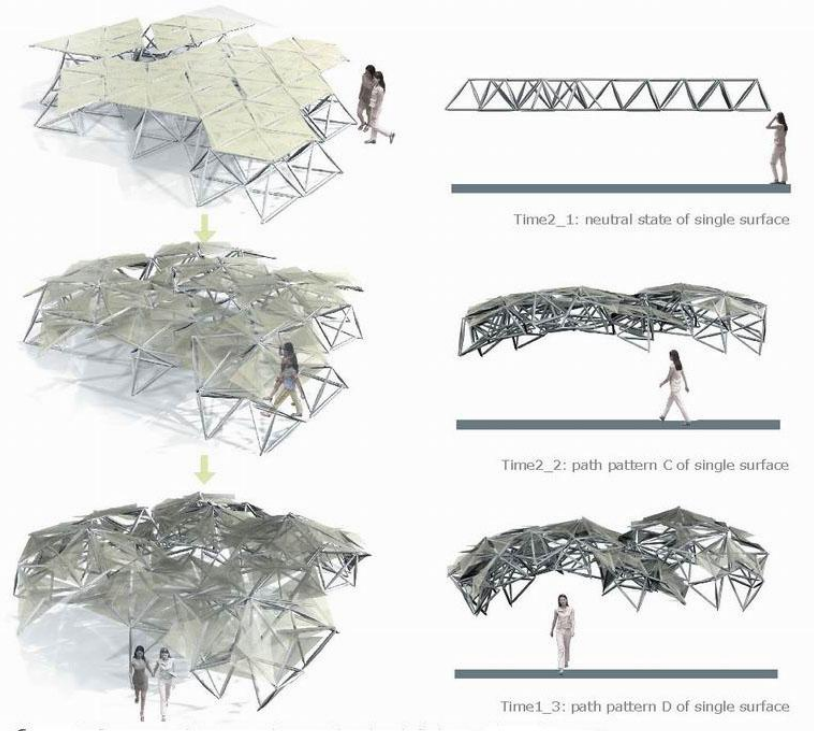
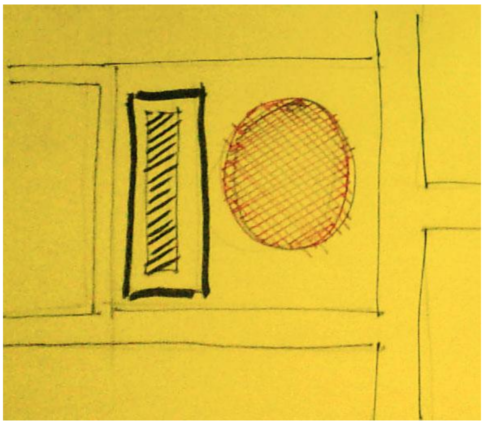


Fig 34: Shell deflection [shabab, 2012]

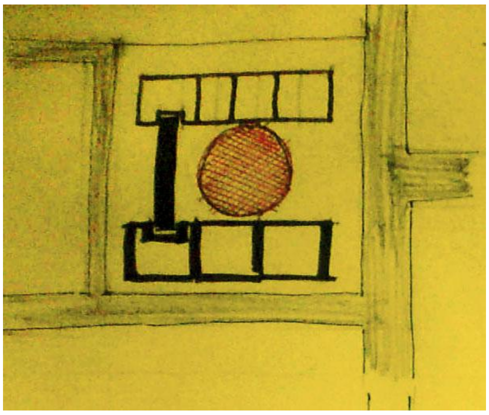
6.6 Design development:

The design development phase is described in details from the beginning till the final proposal.

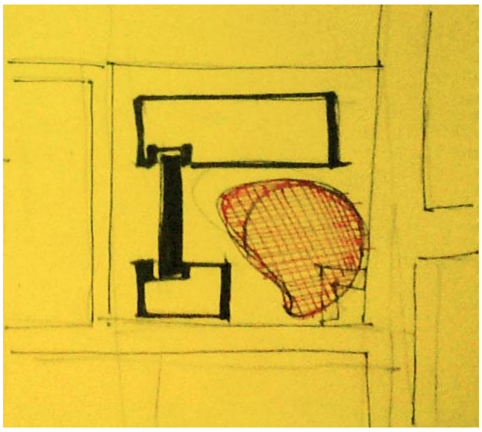
Phase I



The first phase of the project is where the orientation and public access is thought in details. The relation between institution and the public plaza is set in its limit to control.



The plaza is set within the institution buildings to create a sense of enclosure.



At the end of this phase the plaza was made free of enclosure towards the node so that a visual connection can be created from the node.

Fig 35: design phase sketches [shabab, 2012]

Phase II

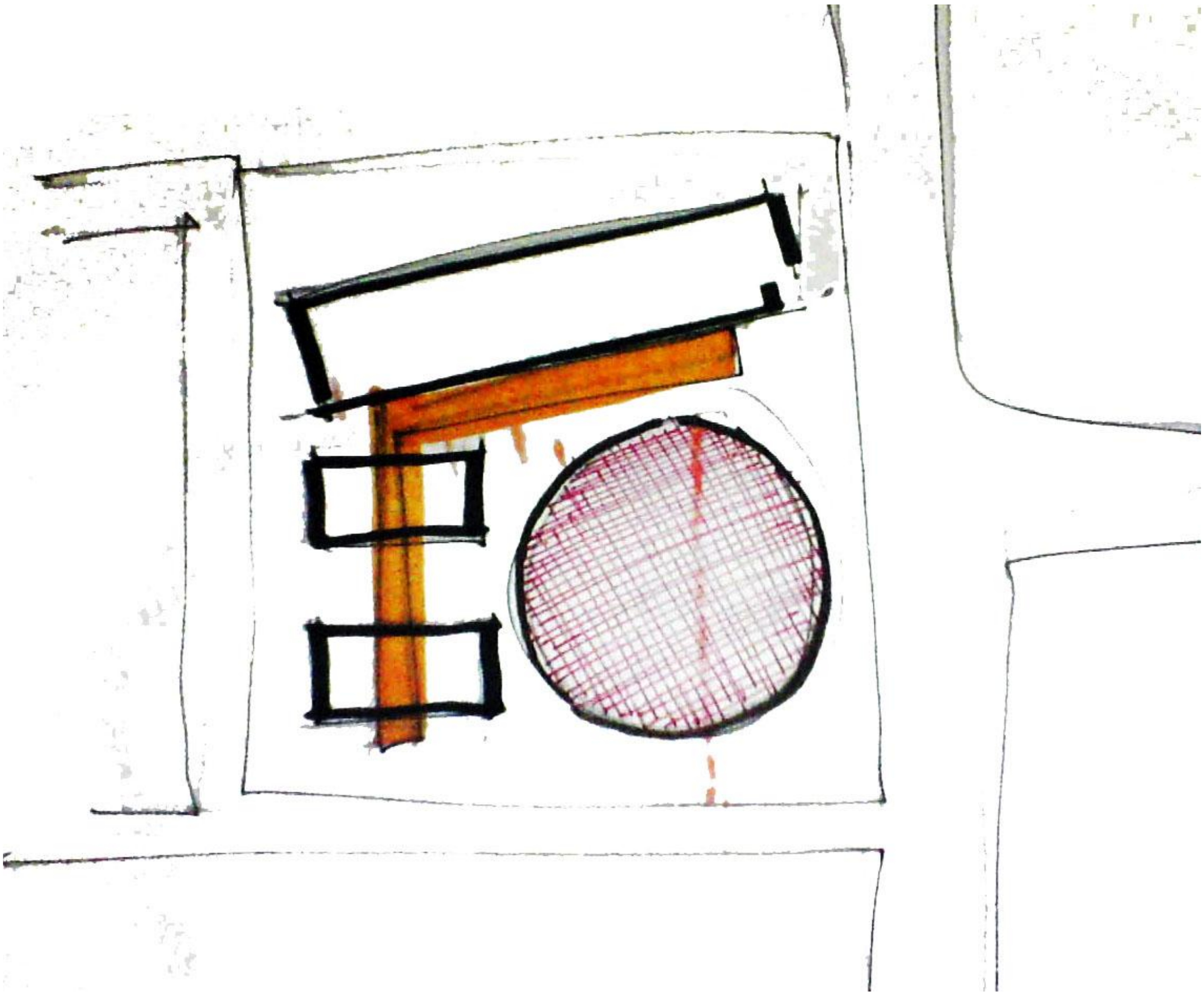


Fig 36: design phase sketches [shabab, 2012]

The second phase of the design was to set identity to the institution mass separated into workshop mass and academic mass.

The workshop mass is then again divided into mechatronics workshop and electric workshop connected by a slender circulation.

The plaza is set to a point that enables people to interact from the pedestrian and is easily accessible from the pedestrian.

Phase III

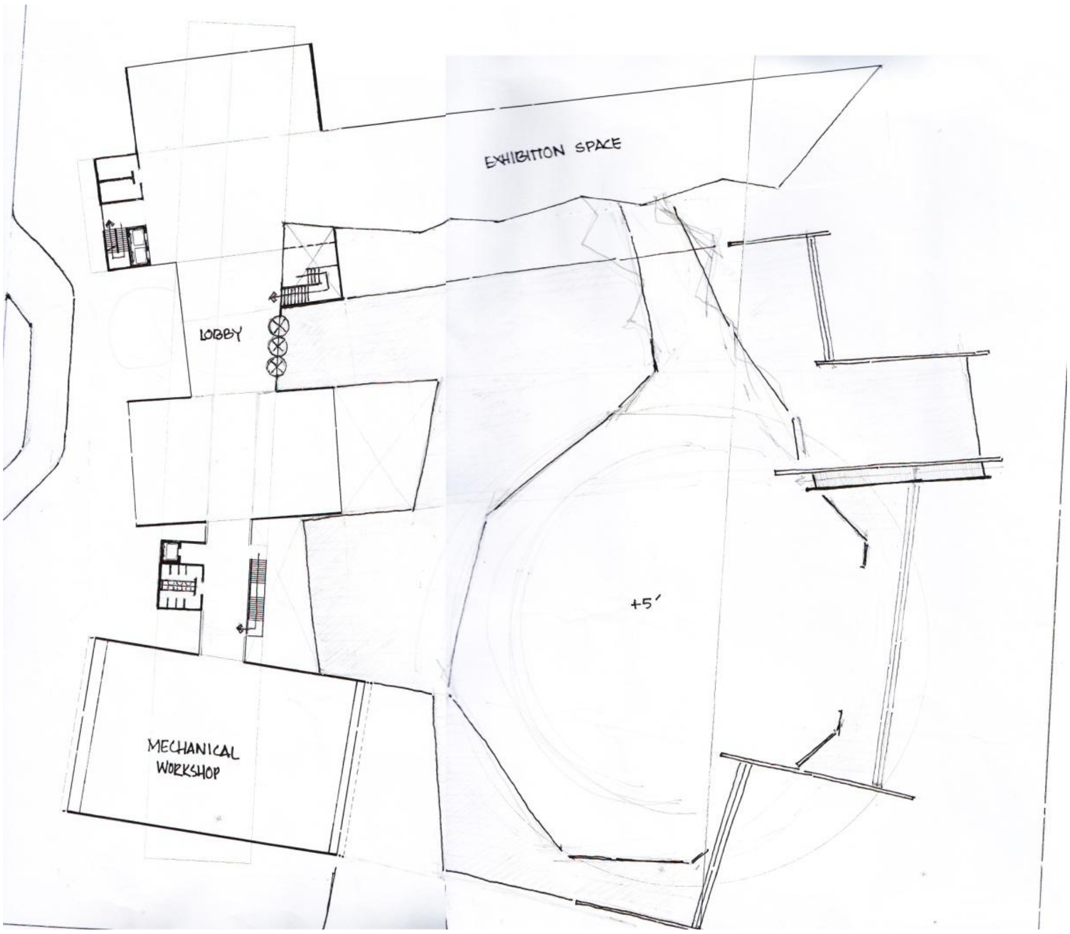


Fig 37: design phase sketches [shabab, 2012]

The third phase is where a link is tried to set within the workshops and academic mass. The plaza also shapes in accordance with the building mass.

The cores are plugged into the circulation and plaza is kept completely separate from the institution mass so as to control direct access into the research facility.

Phase IV

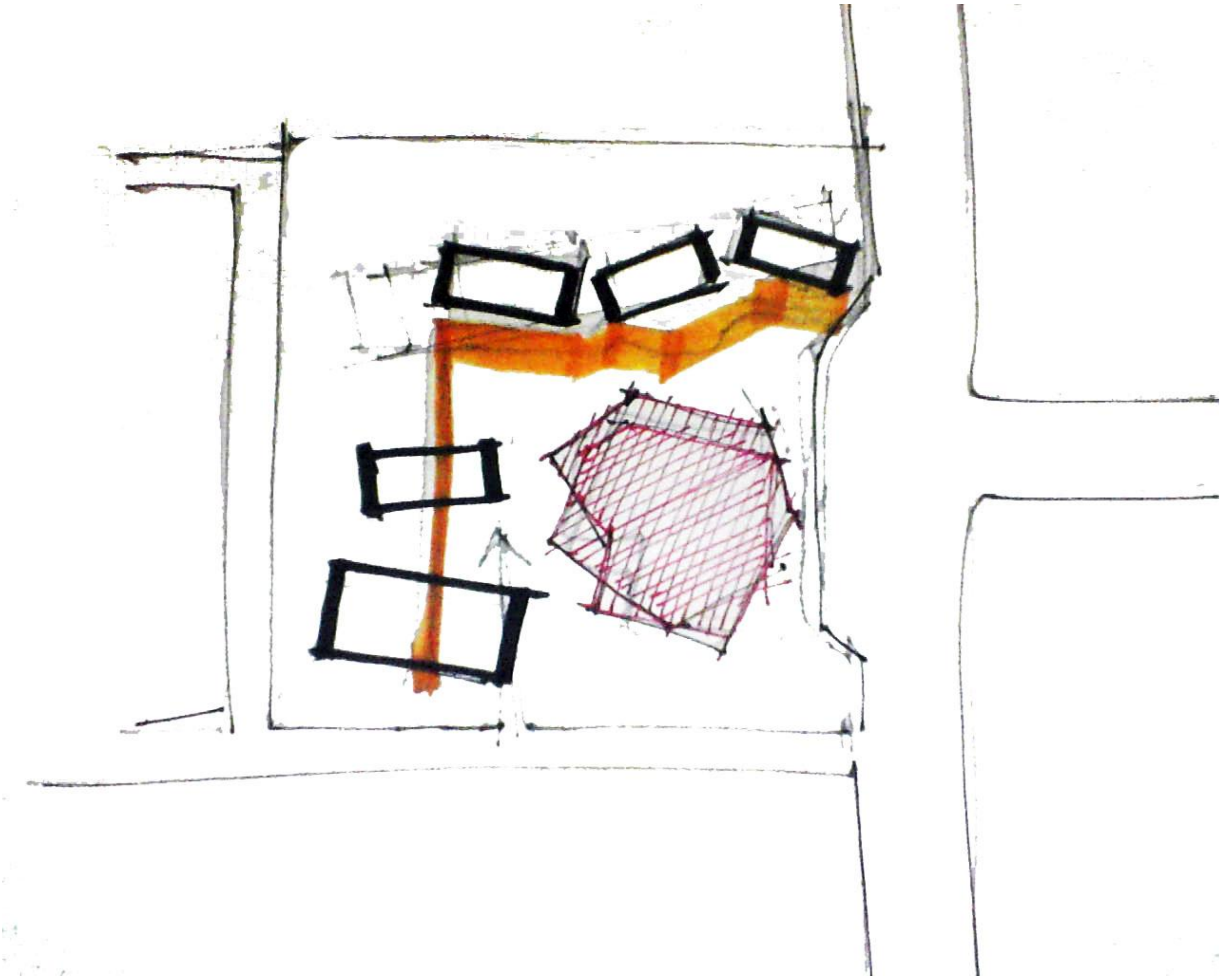


Fig 38: design phase sketches [shabab, 2012]

This is the last development phase where the academic mass is also separated into small clusters resembling the feature of the workshop mass.

Phase V: Final proposal

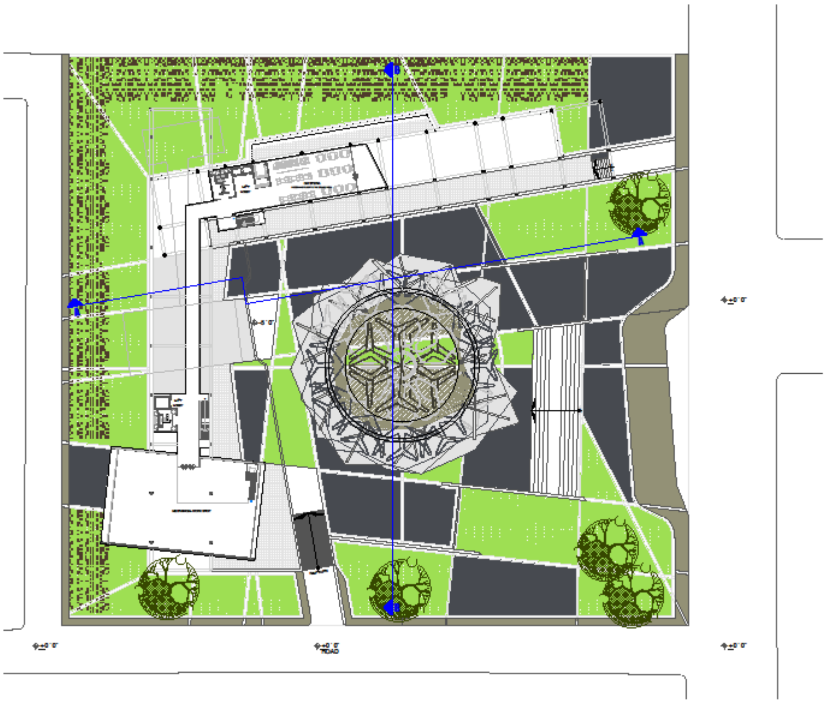


Fig 39: Master plan [shabab, 2012]

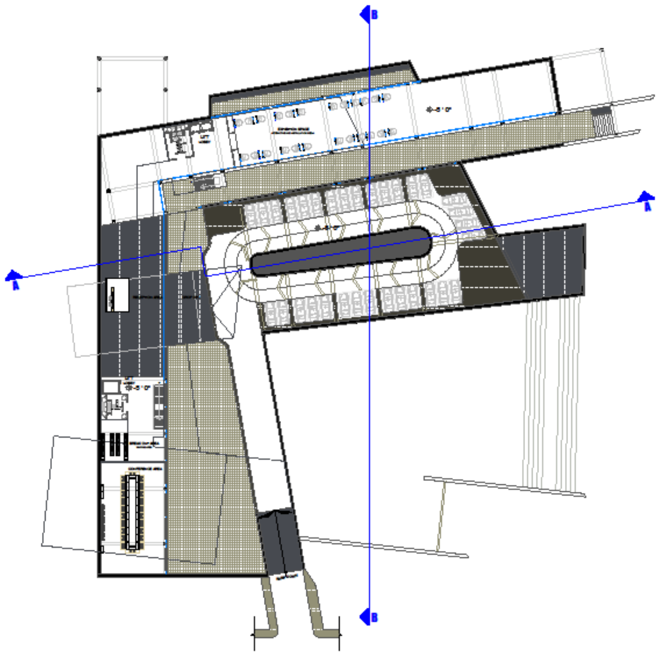


Fig 40: Basement plan [shabab, 2012]

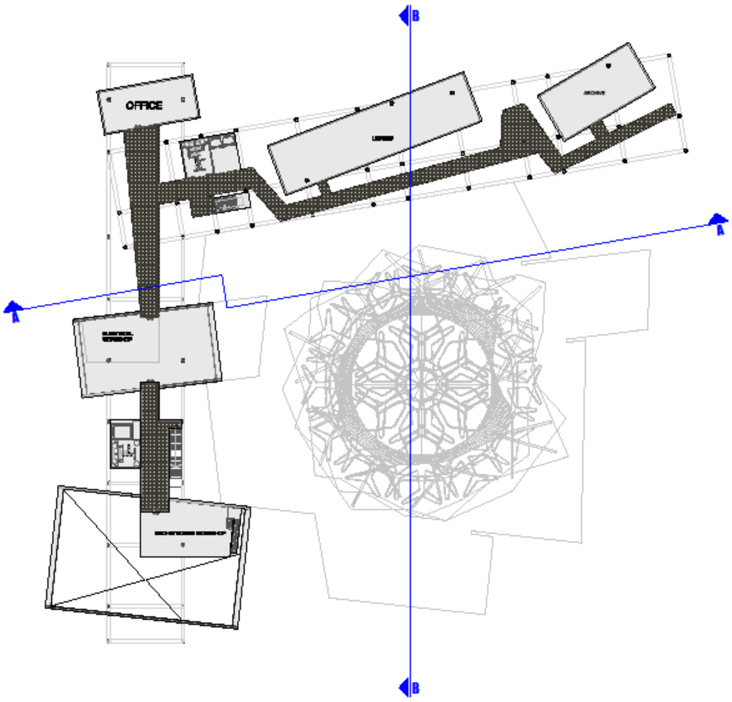


Fig 41: 1st floor plan [shabab, 2012]

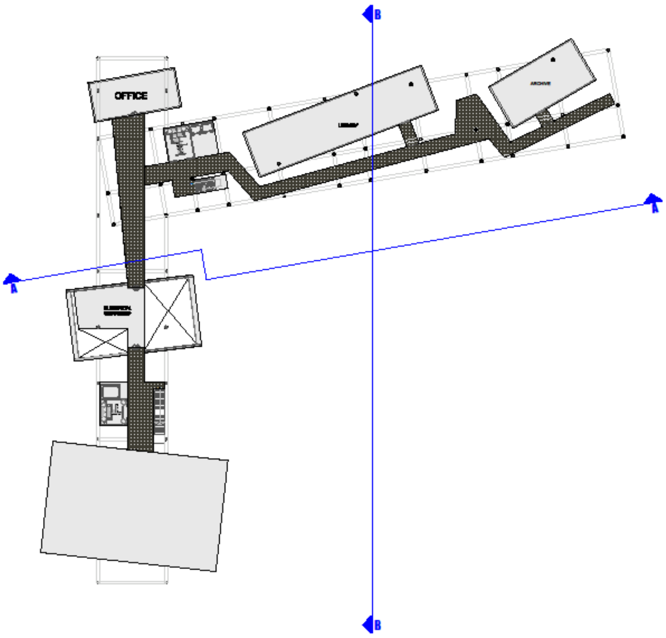


Fig 42: 2nd floor plan [shabab, 2012]

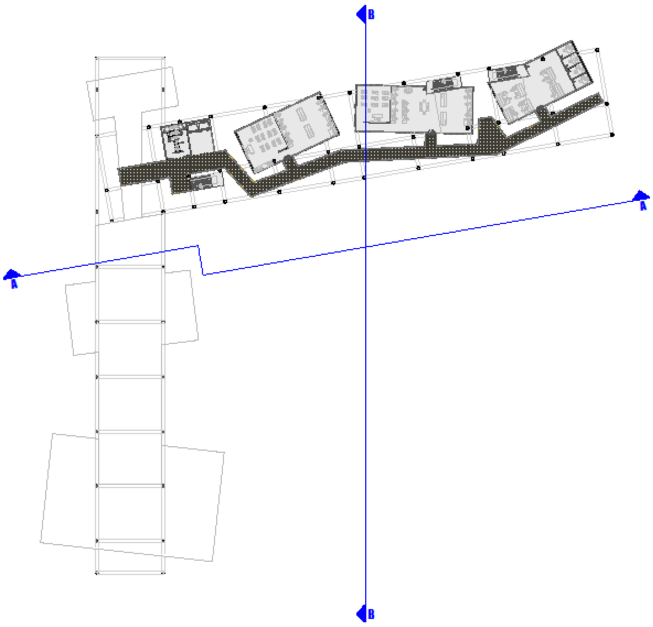


Fig 43: 3rd floor plan [shabab, 2012]

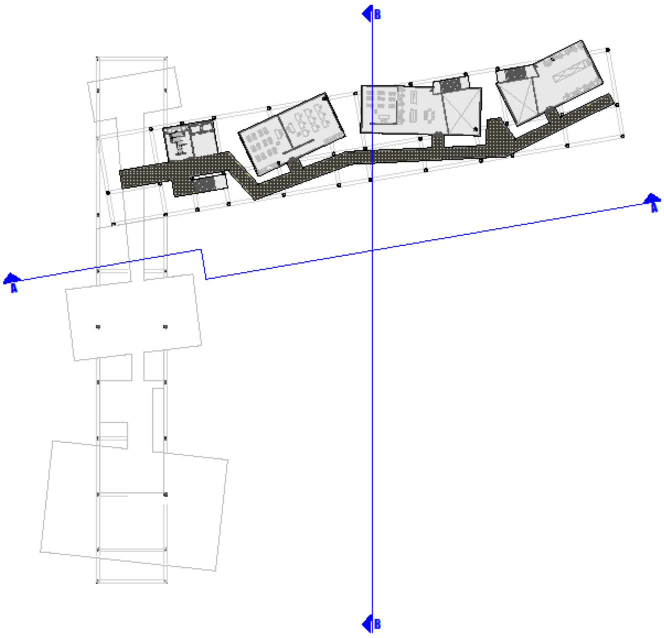


Fig 44: 4th floor plan [shabab, 2012]

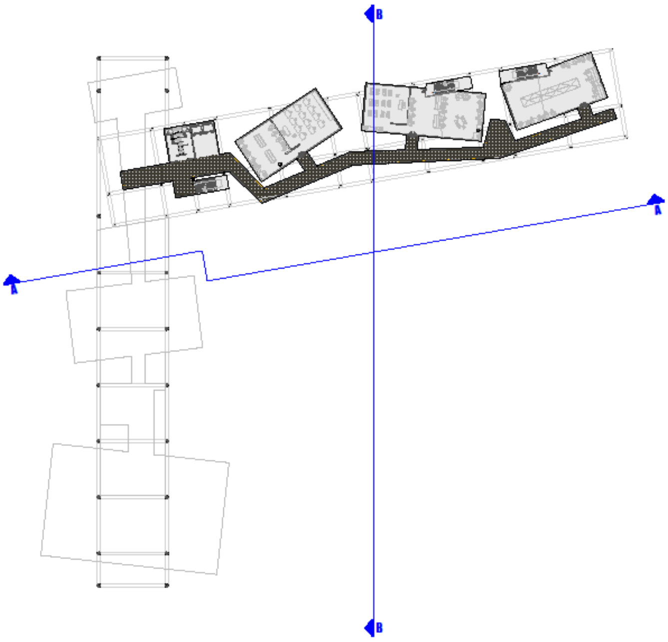


Fig 45: 5th floor plan [shabab, 2012]

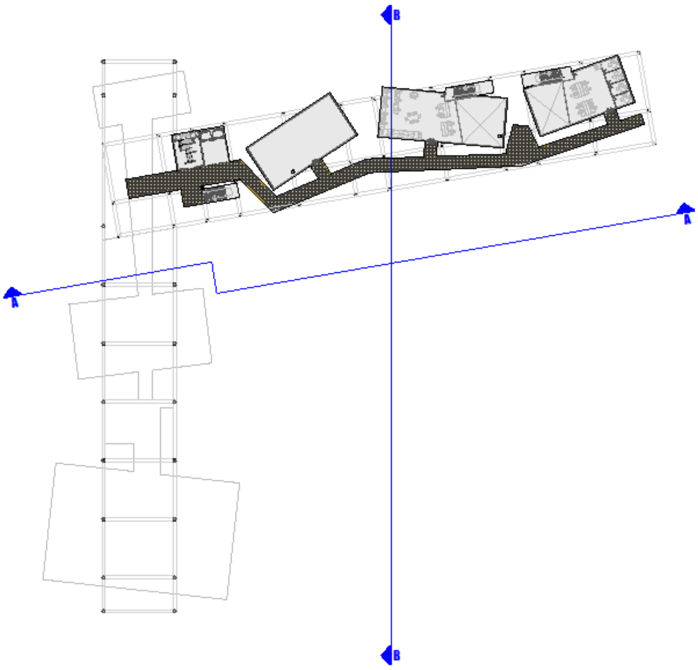


Fig 46: 6th floor plan [shabab, 2012]

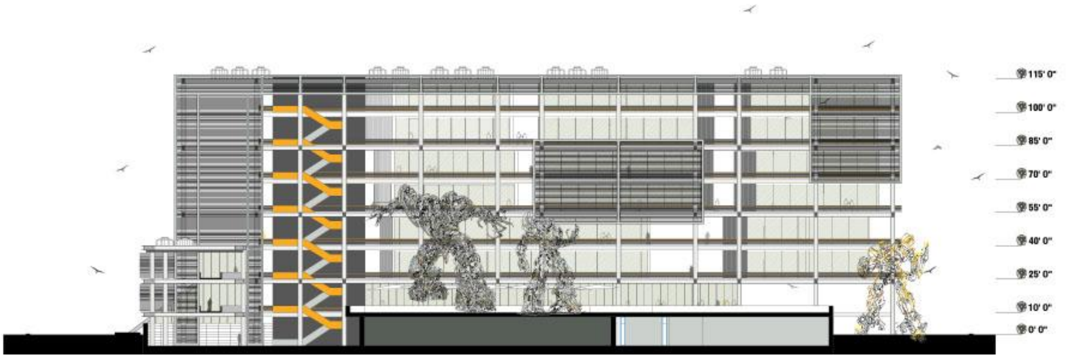


Fig 47: section AA [shabab, 2012]

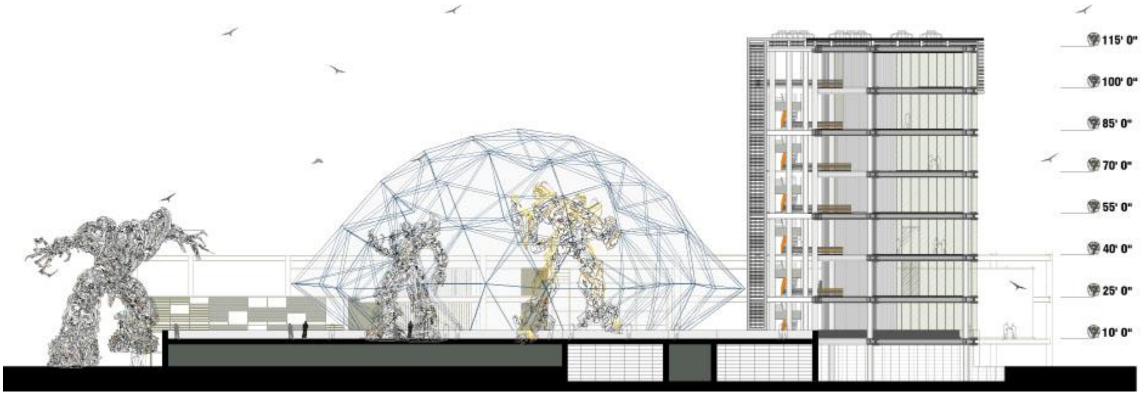


Fig 48: section BB [shabab, 2012]

Model images

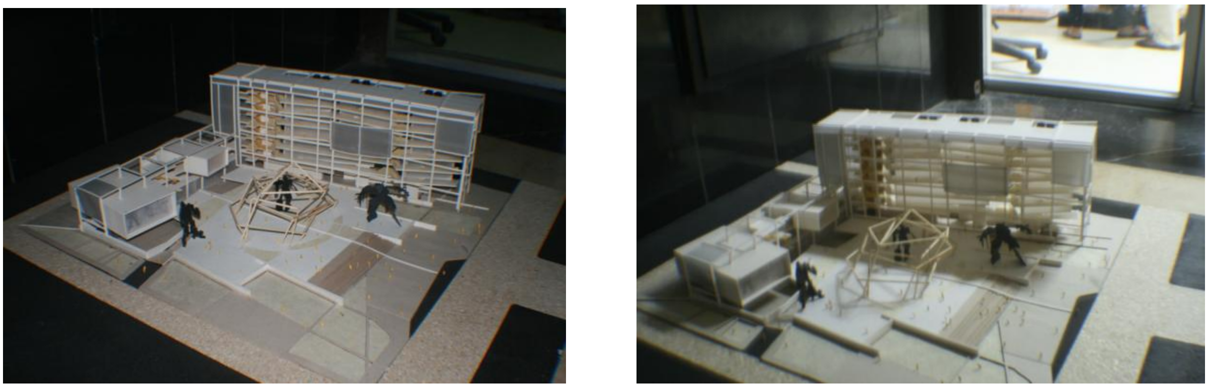


Fig 49: south view [shabab, 2012]

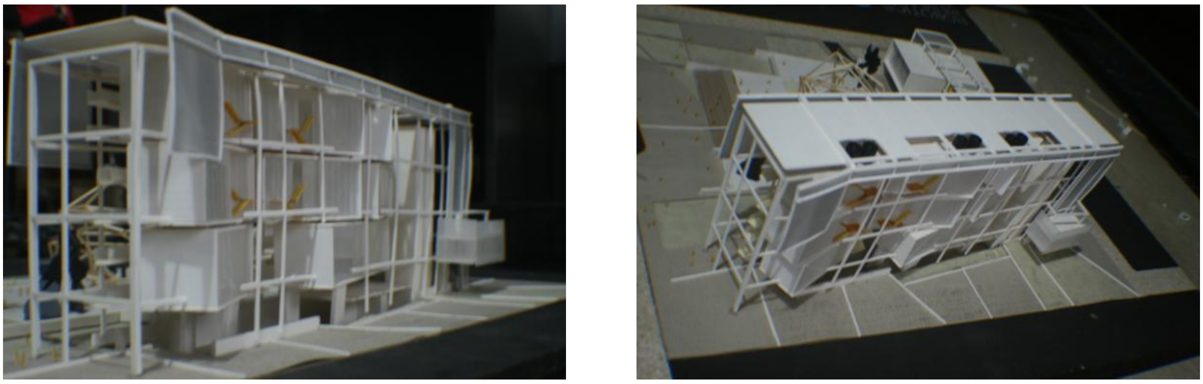


Fig 50: north view [shabab, 2012]

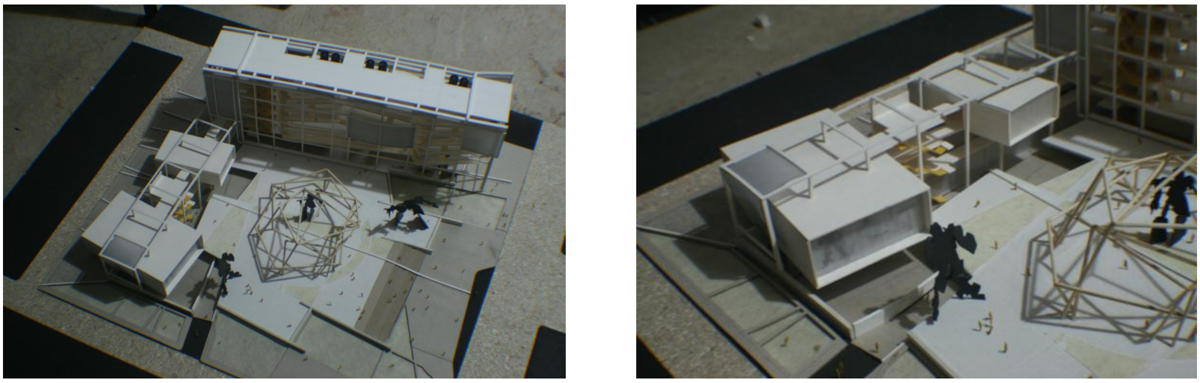


Fig 51: top view and workshop mass [shabab, 2012]

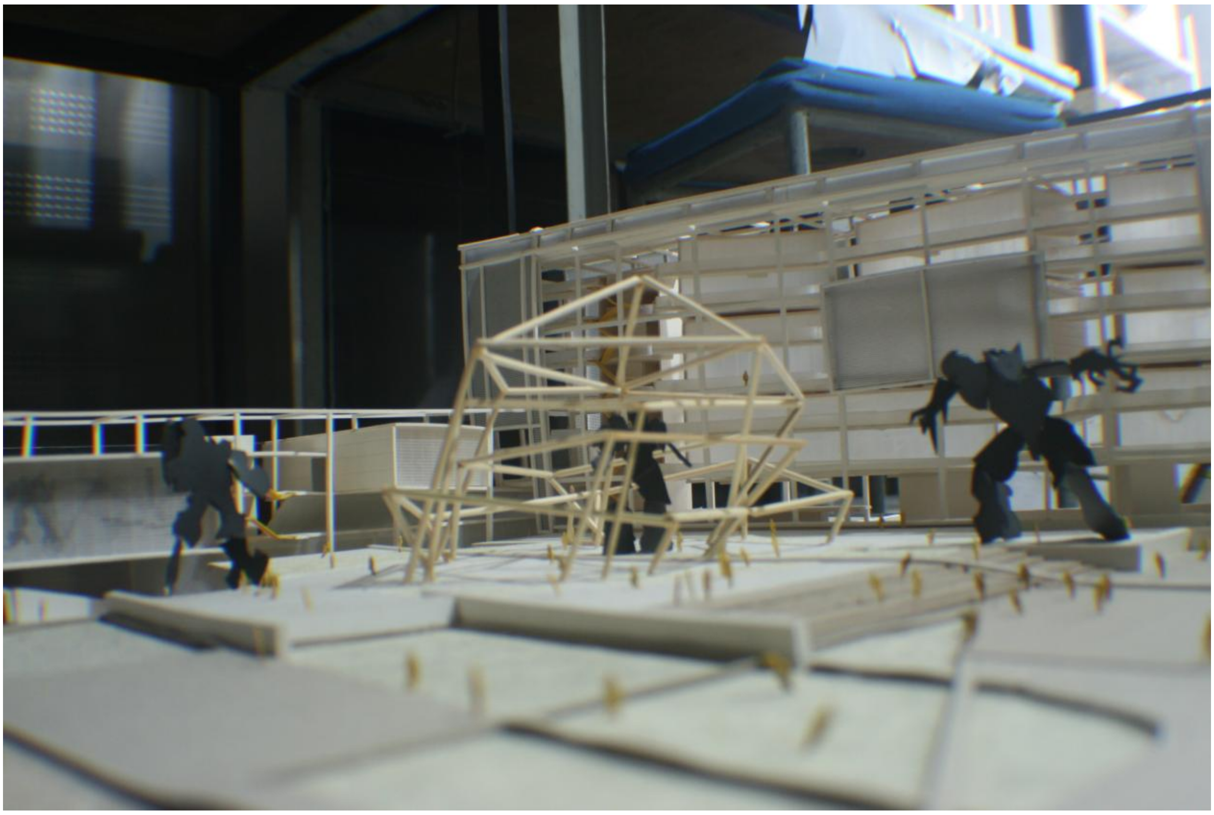


Fig 52: plaza view [shabab, 2012]

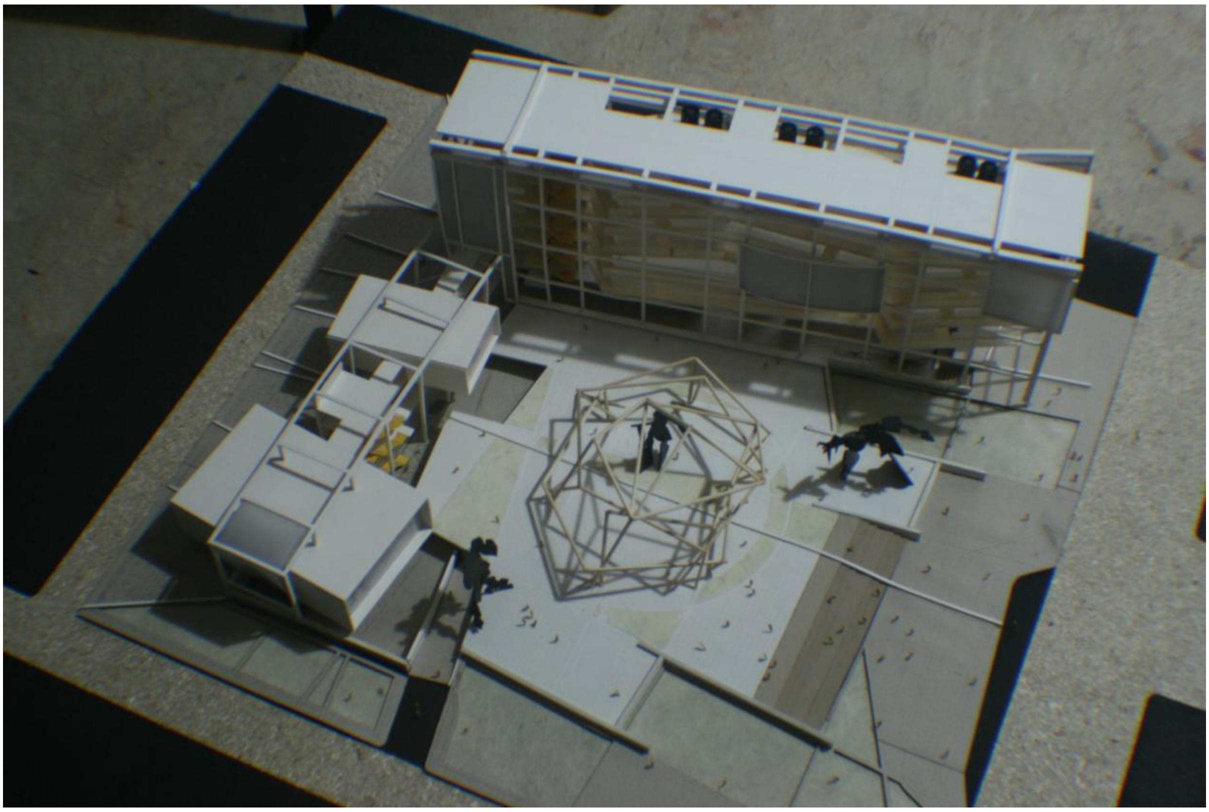


Fig 53: top view [shabab, 2012]

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