SUSTAINABLE DEVELOPMENT IN CONSTRUCTION

MOHAMED A. EL-MIKAWI
Assistant Professor, Faculty of Engineering, Ain Shams University, Cairo, Egypt

ABSTRACT: This paper presents an additional challenge for engineers to deal with the aspect of Sustainable Development in Construction. The role of Quality and Sustainability are explored during the life cycle of construction projects together with the measure of success. The philosophy and principles of Total Quality Management (TQM) are discussed.

The major steps to be considered for sustainable development are highlighted. The creations of Al-Azhar Park along with the development of Darb Al-Ahmar district of Historic Cairo are reviewed as a case study to illustrate the various concepts used for the sustainability of projects in construction.

KEYWORDS: *CONSTRUCTION, MANAGEMENT, QUALITY, SUSTAINABILITY*

1. INTRODUCTION

The building sector is enormously important for the economy, employment and environment. "The construction industry globally represents $3.5 trillion market value and a workforce of around 100 million". (IFBWW, Geneva, August 2002). The awareness of the importance of our belief that improvement is the way of life, Quality and Sustainability became the main concern for engineers.

Quality has experienced a positive change all over the world and in all industrial sectors. Sustainability is relatively new, its philosophy started in the last 15 years.

Accordingly now, Quality and Sustainability are an integral part of the project management process (they are the two sides of a coin). Professional development requires adequate tools to achieve the intended objectives of the project in the best possible way and with the minimum waste and effective use of resources.

In this day and age engineers are educated to design facilities for the whole life cycle taking into consideration the concept of sustainability.

2. SYSTEM APPROACH

The building process is considered as a set of activities going from need to use.
It starts from User's Needs and ends at User's Satisfaction. The process is not linear, but circular or rather spiral. The cause-effect approach moves to a network concept. Figure (1) shows the systematic approach to the quality and sustainability management and continuous feedback to reach the best user satisfaction.

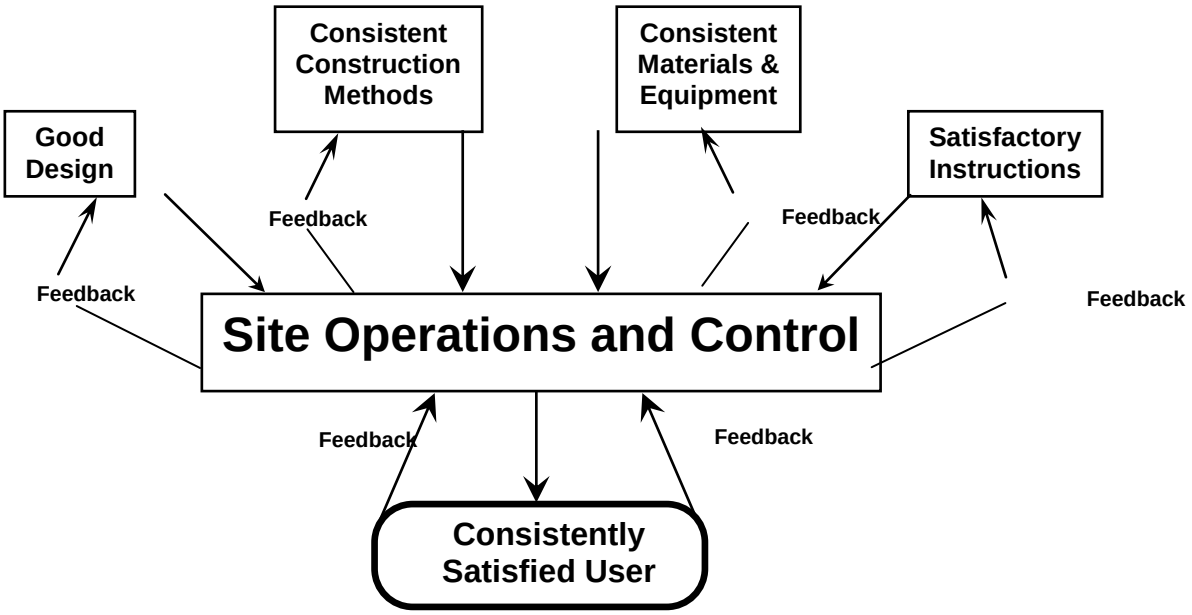

Figure 1: Systematic Approach to Quality and Sustainability Management

A successful building (construction project) should satisfy:

- Function
- Safety
- Economy

3.0 QUALITY

3.1. Definitions

Quality is vague notion. We talk about:

- Quality of production
- Quality of measures
- Quality of Design
- Quality of labor
- Quality of life

Quality can be defined as:

- A degree of excellence
- Conformance to requirements
- Freedom from defects
- Fitness for purpose (Juran, 1992)

In construction prefer to consider ”Quality Target” as it relates directly to function (Hosny, 1994).

In the past two decades, the concept of Quality has experienced a positive change all over the world and in all industrial sectors. The traditional inspection approach has evolved to

Quality Control (QC), Quality Assurance (QA) and finally Total Quality Management (TQM) as shown in Figure (2).

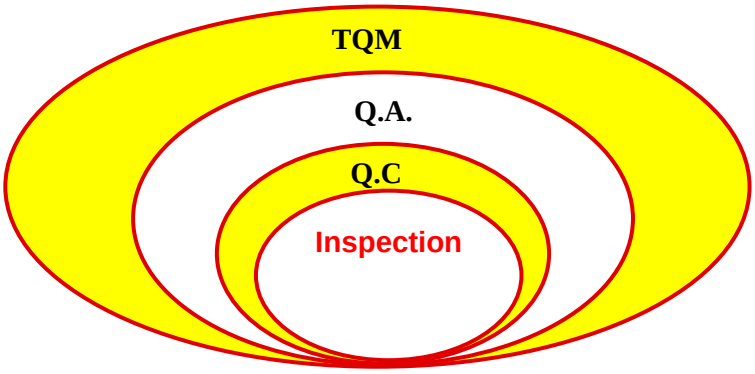

Figure 2: Evolution of Quality

Quality Control is the operational techniques and activities that are used to fulfill the requirements for quality. **Q.C. is a Production Tool**.

Quality Assurance are all those planned and systematic activities necessary to provide confidence that an entity will fulfill requirements for quality. **Q.A. is a Management Tool.**

Total Quality Management (TQM) is the art of managing the whole to achieve excellence. It is both a philosophy and a set of guiding principles that represent the foundation of continuously improving the organization. TQM is the application of quantitative methods and human resources to improve all the processes within an organization and exceed customer needs now and in the future. Philosophy of TQM is to make best use of all available resources and opportunities by continuous improvement. TQM principles must be applied in every branch and at every level of the organization.

3.2 TQM Principles

A TQM principle is a comprehensive and fundamental rule or belief, for leading and operating an organization, aimed at continually improving performance over the long term by focusing on customers while addressing the needs of all other stakeholders.

There are several opinions as the number and nature of TQM principles. It is the author's opinion that the following eight principles represent TQM adequately:

1. Customer Satisfaction
2. Employee Involvement
3. Process Approach
4. System Approach to Management
5. Continual Improvement
6. Leadership
7. Supplier Partnership
8. Factual approach to decision making

4.0 SUSTAINABILITY

Sustainable development covers a variety of complex and sensitive issues, such as employment practices, intellectual rights, community development and rights of indigenous peoples.

In 1987 the "Brundtland Commission" setup by the United Nations, published their report "Our Common Future" and defined "Sustainable Development" for the first time as a "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

In 1992 the world becomes council on sustainable development defined Sustainable Development at the Earth Summit of the UN in Rio de Janeiro as an "Economic process that can be maintained long-term in line with earth's carrying capacity".

Now the term sustainable development can be simply and briefly described by a process towards an improved environment. *Sustainability is seen in 3-dimensions, namely ecological, economic and social-cultural*. Ecological sustainability is focused on 3 protection goals: protection of resources, the ecosystem and human health, Fig.3

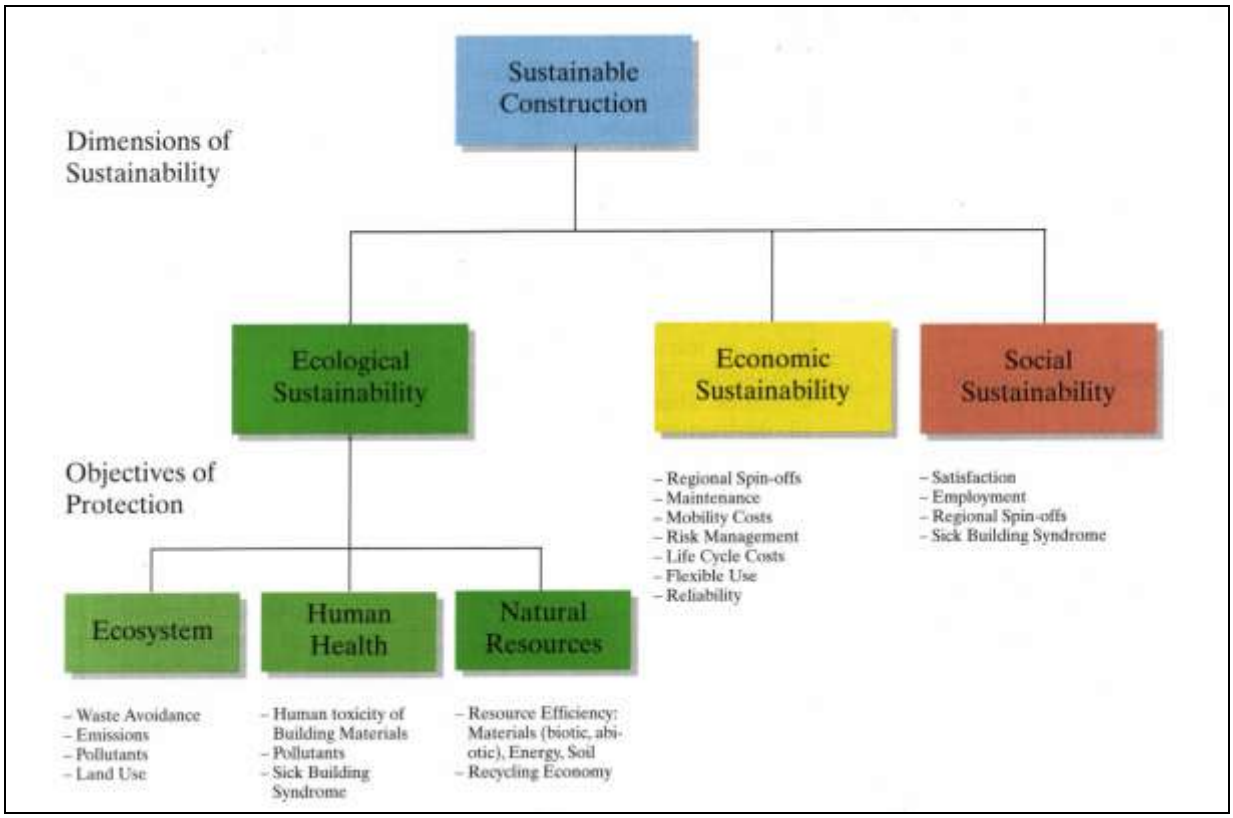

Figure 3: Dimensions of sustainability and objectives of protection

The construction industry has the largest impact on nature and environment. It is one of the main contributors to the depletion of natural resources and a major cause of unwanted side effects:

- Air and water pollution
- Solid wastes & Toxic wastes
- Health hazards

Sustainable development is built on three pillars:

- Economic Growth
- Ecological Balance
- Social Progress

Sustainability calls for new paradigm, Fig. 4

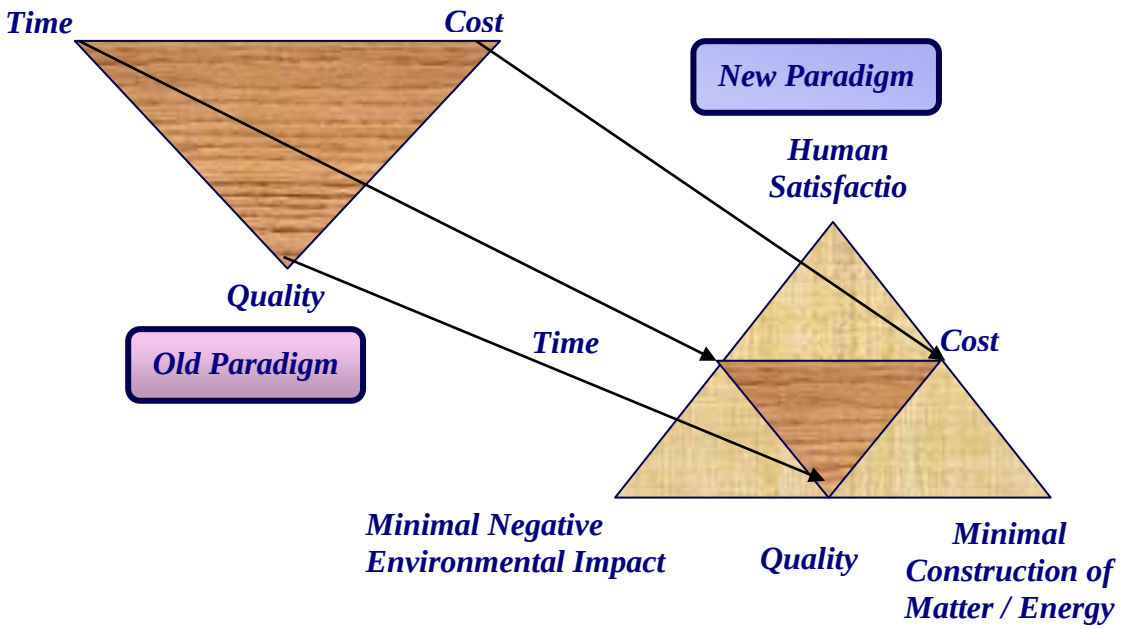

Figure 4: Sustainability calls New Paradigm

Client / end user	Project	Contractor	Society
* Delivery to quality target, time, cost and in a safe manner	* Success for stakeholders	* Reasonable project	* Socio-economic benefit
* Decrease cost of facility without loosing function	* Zero defects	* Client satisfaction	* Minimum environmental impact
* Achieved product performance, operational performance, low maintenance	* Achieved interoperability	* Achieved continuity of work	* Achieved health and safety standards
* Benefit to public by improved quality of business		* Improved professional reputation	
		* Improved competitiveness	

4.1 Eco-efficiency

Eco-efficiency is a new management approach (it is simply a combination of the words economic and efficiency) it is all about producing more from less. It aims to create economic value while ameliorating ecological impact and resources use.
Reducing waste and pollution and using less energy and fewer raw materials are obviously good for the environment. And they are also good for business because they cut companies costs and diminish the like hood on incurring future environmental liabilities. The measure of success for any sustainable construction are listed in table 1
Table 1: Measures to success

4.2 What Should We Do to Deliver Sustainable Development?

- Adopt a whole life approach using life-cycle costing and whole-life environmental assessment.
- Move to Sustainability Impact Assessment instead of just an Environmental.
- Widen Sustainability Construction to Sustainable Development, so as to persuade our clients to adopt new approaches to their development projects.
- Waste avoidance use less energy and water generate dramatic improvement in social conditions. Produce dramatic improvement in the natural as built environment.

Overall, we should be aiming to create appropriate civil engineers works or buildings:

- In the right place**;**
- With a sound choice of materials from the right resources

- With high environmental performance (energy and water consumption, water minimization, maintainability);
- An appropriate design life
- In harmony with its surrounding and neighbors;

So that, with time, this way becomes our norm.

4.3 Steps to be Considered for Sustainable Development

1- **Re-use and improve the performance of existing built assets**, on buildings and civil engineering works, meeting clients' functional requirements may not require new buildings or structures. Refurbishment and/or renovation to improve their sustainability performance may be a better solution than to build new units.

Deteriorated residential buildings in the historic city of Cairo next to the old city walls, built in the twelfth century, were doomed for demolition. Demolition decrees were issued by the local authorities to satisfy policies by the Egyptian Antiquities Organization to clear structures away from the monument. The Government did not move forward with its plans due to the lack of funds to build alternative housing for the residents in new satellite cities.

Meanwhile, the Darb Al-Ahmar project conducted studies which showed that residents wanted to continue to live in the old neighborhood, and that they were willing to participate in the cost of restoring their houses. The studies also demonstrated that the cost of restoring the houses represented roughly sixty percent of the cost of building new houses and relocating people.

Consequently, the project convinced the authorities to comply with international preservation charters, maintaining the fabric of the city and saving the old neighborhood at an optimal cost. Hence, the existing assets were improved and re-used.

2- **Establish any new development in appropriate localities.** We need to avoid inappropriate localities and, ideally, ensure that a new building is in harmony with its surroundings, both physical and human.

The Darb Al-Ahmar project was able to convince local government authorities to issue a special building decree for Historic Cairo maintaining the style of the old city.

Furthermore, the project in collaboration with the local planning department revised the district’s land use plan which was not updated since the mid-1970’s, and took into consideration balancing the resident’s needs with the preservation of the character of the old city.

Furthermore, the project is in the process of creating an implementation unit consisting of a group of professionals and government officials to oversee the implementation of the new plan.

3- **Relate land-use planning to transport and infrastructure.** We need to consider how occupants and / or uses of the facility we build will gain access to it and the impacts of the development or surrounding transport system and infrastructure.

The project was able to conduct public meetings and estimate the resident's needs for the coming years, and draw funds for the upgrading of the infrastructure. Transportation needs were reviewed and due to the constraints of using vehicles in the narrow alleys, and around monuments, vehicular access was enhanced in the district's perimeter.

4- **Design for minimum waste and effective use of resources.** For the whole life cycle we need to design for waste minimization. Specify materials with care and seek more-efficient use of resources. We also need to consider using recycled materials whenever it is appropriate.

The Darb Al-Ahmar project encouraged the use of original building materials like lime stone, tiles, and wooden mashrabias. Many of the old stones and timber were re-used as well in the re-building process.

A lime workshop was set up specifically for the project, and training was offered to contractors on the use of lime in lieu of cement and concrete.

5- **Design for life.** We need to carefully consider the appropriate life of our buildings taking into account likely changes of use and the need for adaptability, plus the need to disassemble it, rather than simply demolish it, at the end of its useful life.

The Darb Al-Ahmar project re-designed the interior spaces for the residential buildings based on tenants' needs. Furthermore, the project was able to gain approval from the Egyptian Antiquities for the reuse of spaces in monuments that were not used for religious purposes. This adaptive reuse brought back important assets to the community. Health centers, early childhood facilities, libraries, training facilities, office space, and community meeting rooms are among the functions that were housed in the spaces that became available by restoring buildings.

6- **Aim for lean construction.** We need to work on continuous improvement in performance, waste elimination, a strong customer focus, delivering value for money alongside high environmental quality, with high-quality management of projects and improved communications with your stakeholders.

7- **Energy consumptions.** We need to design for minimum whole-life energy consumptions, including combined heat and power, passive systems using natural light, air movement and ventilation. Construction in an energy efficient manner and operating built facilities efficiently.

The project started a proto-type for solar water heaters. The initial few heaters were installed, and they have proven to be efficient in their early stages reducing electrical needs.

8- **Do not pollute the wider environment.** Reduce to a practical minimum the chances of polluting the environment surrounding your project. Use a formal Environment Management System that meets the requirement of IS0 14001 or the Eco-Management and Adult Scheme (EMAS).

9- **Preserve and enhance natural features and bio-diversity.** Through out the project phases, from conception to construction of raw materials and landscaping, we must always look for opportunities to provide, improve and protect wildlife habitats.

The project realized the lack of public open space. Hence, the few public spaces were carefully reviewed with the residents aiming to improve them for public use.

10- **Conserve water resources.** We should design for increased water efficiency in building services and for water consideration in the overall built environment, for example using grey water recycling for uses that do not require potable water.

Al-Azhar Park, a seventy five acre park, uses a water irrigation system that optimizes the use of water through a weather station which calculates the plants water needs based on the climatic conditions. Furthermore, the project design took into consideration the use of arid types of plants on the steep slopes overseeing the old city walls built of lime stone. The arid plants provide the required ground cover, but use far less water than grass which is used on flat sections within the park.

11- **Respect people and their local environment, and seek to minimize the adverse social impacts, and maximize the positive social impacts of your project.** Finally we need to involve and be responsive to the local community in planning and understanding our projects. We need to provide a safe and respectful working environment for staff and construction workforce, to design to minimize nuisance to neighbors during construction and operational phases.

Both Al-Azhar Park and the Darb Al-Ahmar community development project conducted extensive studies with the stakeholders of the project, and held public meetings during the design and while implementing the projects to ensure that the community was not adversely impacted. As a result, the design was refined taking into consideration the needs of the people. This continuous feedback is crucial to project success and to achieving sustainability.

5. PROJECT CONTROL SYSTEMS

Figure (5) shows an example for a flowchart of a project control system. It models the operations, flow of information and decision making process characteristics of a feedback control system.

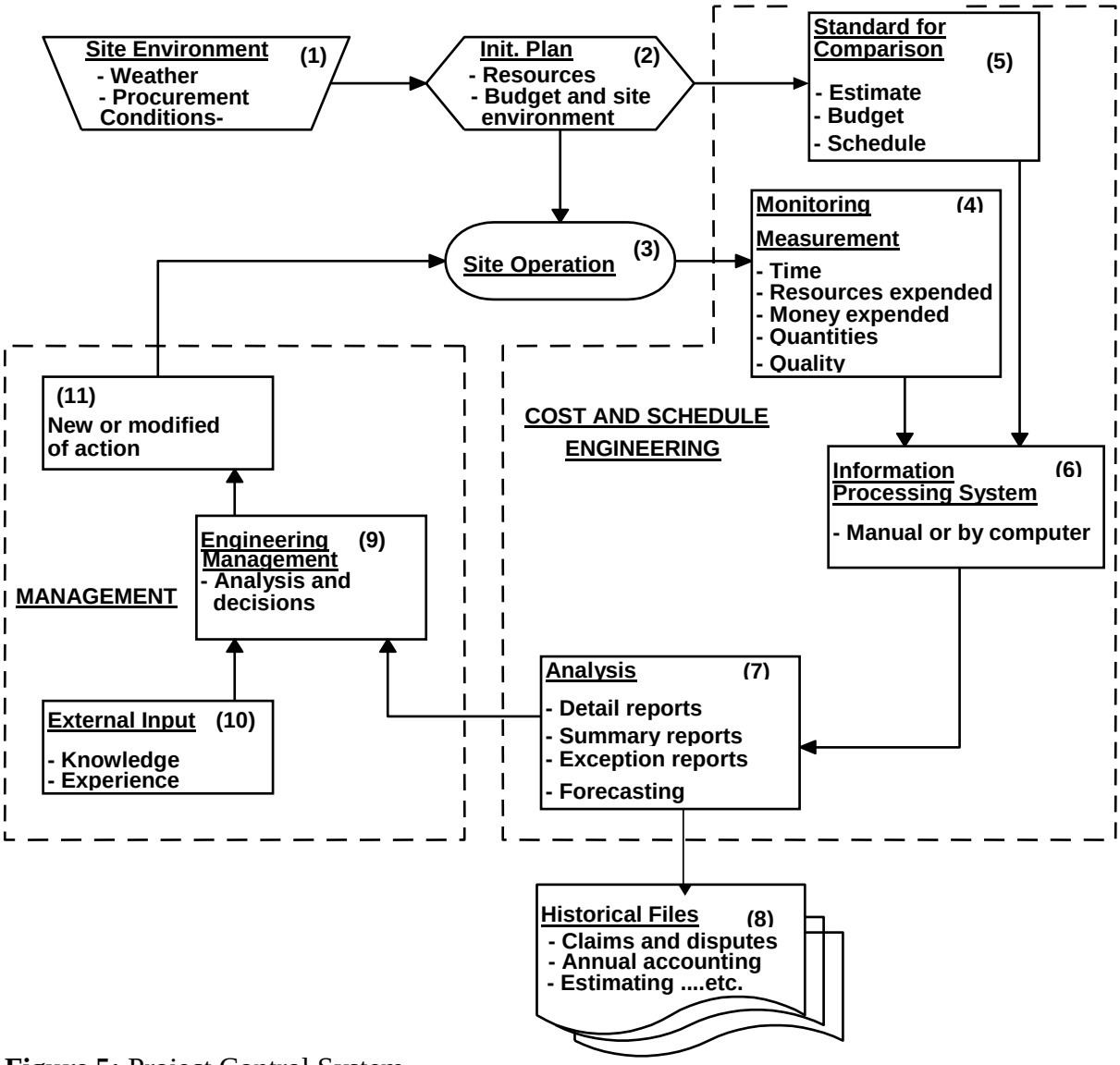

Figure 5: Project Control System

This feedback system was practically applied in the Cairo Metro Project using Progress Curves (S-Curves). The analysis of step (7) in the flow chart and specially the exception reports during the period from June 1983 - December 1983 showed that progress was in delay for more than one year and the trend of the actual progress shows that the project will need twelve years to complete and all parties involved in the project were in tension. However, analysis of the exception report showed that the main reasons of the delay were, shortage of machines for placing the diaphragm walls, extra amount of injection materials are needed and smooth access to site is required.

The decision to mobilize an extra machine, approve extra amounts for injection and planning in advance for access to site with local authorities, was taken in due time.

Following the results on the S-curve in December 1984 showed that the progress is satisfactory and the project could be completed on time.

6. ECONOMICS OF QUALITY CONFORMANCE

The increase in Quality Conformance is usually accompanied by increase in the construction cost, while the quality cost decreases with the increase of quality conformance. The total cost is the sum of construction cost and quality cost. For economic solutions we seek for optimum quality and minimum cost. See Fig. 6 and table 2.

Table 2: Quality in the Project Life Cycle
(As per R.C. Code of Practice, No. 208, 1995)

Activity	Purpose	Remarks
1- Concept & Feasibility	To focus & define quality target	Performance Requirement
2- Design	Specify quality	Technical solutions
3- Planning for Construction	Quality Assurance	Prepare Tender Documents including Quality Requirements
4- Construction	Produce & control Quality	Plan & Control Activities
5- Delivery	Verify Quality	Quality of Building & Quality of Record Documents
6- Operating & Use	Keep Quality	Periodical inspection & Maintenance

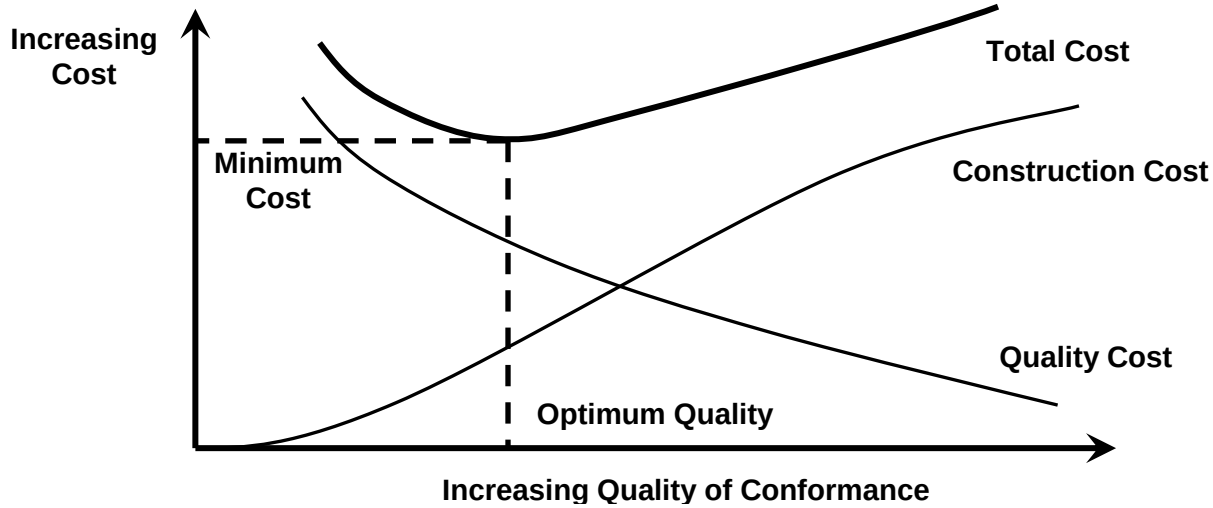

Figure 6: Economics of Quality of Conformance

7. CONCLUSIONS

The construction industry has the largest impact on nature and environment. The building value increases with the right maintenance, while the value of industrial products usually decrease with time. We should design buildings for the whole life cycle, considering the 3 dimensions of sustainability, ecological, economic and social-cultural.

Application of *Quality and Sustainability principles* to buildings is invaluable to the economy and social benefits of the community. At the same time we can achieve lower costs for the total construction and operational costs during lifecycle of the building.

Hence the construction industry should adopt measures to improve the sustainability of its projects which are summarized as follows:

1. Re-use and improve the performance of existing built assets
2. Establish new development in appropriate localities
3. Relate land-use planning to transport and infrastructure
4. Design for minimum waste and effective use of resources
5. design for life
6. Aim for lean construction
7. Seek efficient energy consumption
8. Reduce pollution
9. Preserve and enhance nature
10. Conserve water resources
11. Respect people and their local environment

A significant number of these measures have been adopted in western nations. However, under developed countries should be encouraged to follow. Enforcement could begin with constraining funds for large projects from international financial institutions to governments till these measures are adopted

REFERENCES

1. **A. H. Hosny**, (1993), ” Managing Quality for Construction Project”, Conference on Project Management, Abu Dhabi, 5-7 Dec. 1993
2. **A. H. Hosny, and K. Hamdi (1999)**, ” Quality Management in Construction, The Current state of Affairs in Egypt”, ASCE Middle East Regional Conference and 2nd International Symposium on Environmental Hydrology-May 1999
3. **A.H. Hosny (2000)**,” Controlling the Quality of Construction Projects”, Seminar at Imperial college, London, U.K., March 2000
4. **A. H. Hosny (2003)** Quality and Sustainability in Construction, Alex. Conference on Geotechnical and Structural Engineering, Dec. 2003.
5. **IFBWW (2002),** ” Sustainable Industrial Development- a Trade Union Perspective” , August 2002
6. **ISO 14000, (1996)**
7. **ISO 9000 (2000)** : 3rd Edition
8. **Peter Maydl (2004)** Sustainable Engineering: State of the Art and Prospects. SEI Volume 4, No.3 August 2004
9. **I. Osman (2003)**, ”Partnering and PPP in Construction”, 8th International Conference, Leading the Future in Construction , CICA Cairo, Egypt, Oct. 2003