THE READY MIX INDUSTRY – WHAT NOW ?

By

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ABSTRACT

The growth of the Ready Mix Industry particularly over the decade prior to the Asian crises was nothing short of spectacular. The industry is yet again cranking up to meet the expected growth of the construction sector fueled primarily by public sector demand. The question remains to be asked: How can the Ready Mix Industry meet the continuing industry challenges, including low productivity, a small labour pool which is generally unskilled and the growing demands for low maintenance structures. The answer may be in Technology and refocusing the industry.

The author will consider developments in concrete technology used widely in Japan and Europe such as flowable self-compacting concrete and low penetrability concrete used to achieve design life targets, and their appropriateness for the Malaysian environment. The need to reposition the Ready Mix Industry to service the growing pre-casting market and the identification of training needs will also be discussed.

RECENT ACHIEVEMENTS IN THE CONCRETE INDUSTRY

In the last decade Malaysia has been the center of some of the largest building and infrastructure projects. The construction Industry leap frogged into the era of modern advanced technology in partnership with major foreign contractors, architects and consultants. Projects of high visibility were achieved including the Petronas Twin Towers, the Light Rail Transit System 1 and 2, the Singapore-Johor Second Crossing and the New Telekom headquarters to name but a few.

The World's Tallest Building The Petronas Towers [1] in particular put Malaysia in the international map. The project was realized with American Architectural and Structural Engineering inputs and built by contractors from Japan and Korea. Besides the involvement of a leading local Consulting Engineering Company as a joint venture partner in structural design, the high strength concrete (>100 Mpa) was successfully supplied by local players at a time when the normal concrete supply was only Grade 25 to 40 Mpa .

Today the delivery of high strength concrete by the local ready mix industry is not an issue and the benefits of this have been realized on several projects. The leading Malaysian structural consultant involved in the Petronas Twin Tower Project went on to be the main consultant in another impressive project which has taken shape in Kuala Lumpur, the new Telekom head quarters [2] in Pantai, a 77-storey building of stunning architecture and complex engineering. The Telecom head quarters was another highly visible project which required excellence in concrete technology and the use of High Strength Concrete (HSC). In this regard special approaches were developed to achieve transfer beam pours at level 3 and the use of 70 Mpa concrete for the lower level columns [2]

It should be noted that in the early 90's the use of High Strength concrete in design of tall structures was a relatively new development. No codes adequately provided for this and there was even less information of its use in a tropical environment. A limited amount of applied Research and Development on HSC, related to constructability issues, was undertaken by the Author [1] on behalf of the contractors during the Petronas project inception. However much more could have been done to monitor the structures built with HSC and learn from this experience in a tropical setting. Such a move could have provided the Malaysian construction Industry the international recognition for engineering skills and an edge for other similar projects in the tropical belt. In the event, besides the transfer of design skills and the development of the ready mix supply availability there was no focused attempt to achieve excellence in this regard.

The STAR LRT System 1 was another project where advanced technology such as the balanced cantilever method and match-casting of structural elements for viaduct construction was successfully undertaken for the first time in Malaysia. Here the off site manufacture of pre-cast structural elements with blended concrete mixes was achieved. Similar approaches were taken for the system 2 LRT development in the City which followed. The transfer of skills to local entities has now resulted in a skills base in viaduct construction which is increasingly a feature in infrastructure developments the world over.

We must however accept that the local construction industry cannot be a world leader in all aspects of construction. There is a need therefore to identify a vision for the future. A good example of the latter is the construction of the North-South highway where through foreign involvement Malaysian contractors / consultants developed expertise in highway construction and build-operate transfer techniques. Today Malaysian led consortia are winning major road infrastructure projects in India and it is a reality that much of the privatized road projects in Malaysia in the last 5 years have been undertaken by local consortia. The Ready mix Industry could provide such a focused vision for the development of expertise in HSC for high rise structures. Such transfer of technology and development of expertise needs to be planned as part of the vision for the future.

The emerging global market allows the worlds best contractors and consultants to work in any country without restriction. There is simply no room for mediocrity. Underpinning such a move forward will be a highly skilled, well rewarded and confident workforce at all levels of the Industry.

THE MALAYSIAN READY MIX INDUSTRY [3]

The Concrete Ready mix industry has gone through a tumultuous time since the Industry reached its peak in 1996 with a supply volume of 16.5 million cubic meters. The downturn of 1997 took unimaginable tolls and the Industry went through a period of consolidation with the smaller players unable to survive resulting in several mergers. Concrete usage plunged to 9.5 million cubic meters in 1997 and only managed to achieve 11.5 million cubic meters in 2001 though this does represent a steady growth in the industry in that time. The market volume for ready-mixed concrete in Peninsula Malaysia for the year 2002 is estimated to be in the region of 11.0 to 12.0 million cubic meters. This does suggest a continuing over capacity which needs to be absorbed in the future. There are over 3000 concrete trucks in service and usage currently is only 400 cubic meter per truck compared to 600 to 800 cubic meters before 1997. The industry is however showing signs of growth with public sector projects steadily on the rise and the general economic outlook becoming more positive. The Government has revised its forecast on the GDP growth to 3.5 per cent for 2002 and has rightly given priority to certain infrastructure projects. The recent waiver of stamp duty for the purchase of new houses, from Jan to June 2002, will further encourage developers to launch housing projects at locations where there is still demand.

The problems of low productivity and a small unskilled labour pool are likely to be obstacles to meeting the future challenges to the industry. A concerted effort is needed to overcome the inherent limitations of the local industry in meeting the future needs of the construction sector. This includes considering application of technology such as self-compacting concrete for increased site productivity and the development of high performance concretes for achieving better life cycle cost strategies for our structures.

SELF COMPACTING CONCRETE – AN OVERVIEW

Introduction

Since its introduction in Japan some 10 years ago [4] self compacting concrete (SCC), a high performance composite which flows under its own weight over a long distance without segregation and without the use of vibrators, has found numerous applications particularly in Europe. The initial impetus for the development of SCC was the acute shortage of construction workers in Japan and this continues to be an important factor in its continued application.

The complete elimination of the consolidation process achieved with SCC can lead to many benefits [5] and includes

2. Better quality concrete where access and congestion of reinforcement are unavoidable.
3. A reduction in the number of workers on site.
4. Provides for a better working environment including a reduction in noise.

The reduction in overall construction costs has been quoted as generally in the order of about 5% in the European and Japanese context.

Despite these benefits the usage of SCC worldwide has been limited, primarily due to its high supply cost. Depending on the supplier, the cost ratio of SCC to normal concrete of similar strength grade can be as high as 3 [6]. In Sweden where the industry is highly competitive and with materials locally available, SCC is only 1.10 to 1.15 times the cost of normal concrete. [5] In Germany and Japan this cost goes up to 1.5. [6] Closer to home in Singapore where the application of SCC is still in its infancy the cost of SCC is about 2.5 times but values between 1.8 and 3 times the cost of normal concrete have been quoted [6] . Based on local information from members of the Ready Mix Industry the typical costs in Malaysia are likely to be between 1.5 to 2 times normal concrete. These cost have necessarily confined the use of SCC only to special projects.

Key Parameters

Fresh SCC must possess high fluidity and high segregation resistance. Fluidity means the ability of the flowing concrete to fill every corner of the form as well as being able to pass through small gaps between reinforcing bars. This is often referred to as filling ability and passability of SCC respectively. To satisfy these requirements the aggregate size is generally limited to 25 mm and the amount of coarse aggregate is reduced as they require a lot of energy in moving them. The latter is balanced by an increase in paste volume, which has the effect of increasing the aggregate interparticle distance thereby reducing the possibility of contact and lowering the aggregate to aggregate friction. This aggregate reduction needs careful consideration as coarse aggregates serve a useful purpose in controlling creep and shrinkage as well as stiffness and ductility of the hardened concrete. To achieve high fluidity, Superplasticiser (SP) is added to the mix to lower the water demand. The common SP used is a new generation type based on polycarboxylated poly ether which acts as a surface-active agent causing dispersion and consequently reducing the friction between the powder materials. This SP is considerably more expensive than the traditional SP used in normal concrete and is one element of the high cost of SCC.

To achieve high segregation resistance the powder content i.e. cement and fillers is higher than normal mixes with contents ranging from 450 to 600 kg per cubic meter. SCC normally incorporates some 200 kg.m3 of fillers. Experience in Japan and Europe suggest that there are a wide range of materials and proportions that can be used to produce satisfactory SCC, with certain key factors falling within the limits shown in Table 1 [6].In general however mix designs must satisfy the criteria on filling ability, passability and segregation resistance. For economical mixes the powder content should be kept to a minimum because the cement and limestone powders are both expensive items. In practice the normal test methods such as slump cannot be used for SCC and special test methods have been developed as illustrated in Table 2 & 3. The Slump flow and either the L-Box, U-Box or V-funnel tests are commonly performed for the production of SCC. It should be noted that the suggested limits given in Table 1 do not necessarily guarantee satisfactory performance of SCC. In any case these limits are obtained mainly from Japanese and European experience and may not be applicable to our local conditions. These will need to be verified locally and guidelines in the use of these limits should be developed to assist engineers to specify SCC correctly.

Although the cost of fillers is similar to Portland cement in Malaysia any attempt to use cement entirely as the powder content should be resisted due to heat of hydration issues and propensity for cracking. The use of Blended cements such as a 50/50 Portland Blast Furnace slag cement should be considered as this has the advantage of lowering heat of hydration as well as water demand. The latter has the additional benefit of improving the segregation resistance of SCC. Other advantages include less bleeding which means SCC can be finished earlier compared to normal concrete. However due to less bleeding

SCC is more prone to plastic shrinkage cracking which means more attention should be paid to proper curing.

Conclusion

Some of the latest developments in SCC are discussed above but the cost of supplying SCC has to come down before a more general application to construction is possible. It is likely that as the volume of usage continues the cost of SP for instance will come down. While the current economic conditions prevail i.e. overcapacity in concrete production, the non-existence of large fast track projects and the ready availability of workers, it is not conducive for SCC to have a wider application. However as the economy moves forward from the ravages of the 1997 downturn and there are already signs that growth of the industry will continue, the problems of skills shortage and concrete availability may become a reality again. The ready mix industry needs to invest in Research and Development in SCC and begin to educate potential clients on its benefits for future projects. This will provide a basis for SCC to be specified in projects enhancing the prospects of these higher margin concrete mixes being used by the industry.

CONCRETE DURABILITY [8]

Introduction

Durability Design is currently based on a deemed-to-satisfy approach. Limits are given for w/c, strength grade, cement content and cover, and if these requirements are met the structure is deemed 'durable'. This approach would have been considered acceptable if the observed occurrence of premature deterioration was low. However, corrosion of reinforcement continues to represent the single largest cause of deterioration of reinforced concrete structures worldwide. The problem is variously attributed to inadequate specification, poor detailing and construction defects, such as poor compaction or curing or low cover.

In addition to failing to keep deterioration to an acceptably low level, the deemed-to-satisfy approach is limited in several other major respects. Principally it fails to recognize that structures deteriorate progressively. When a design life, of say 50 years, is specified it clearly does not mean that the structure will suddenly deteriorate to a state of unserviceability after 50 years. Often deterioration will commence before the design life is reached, as all materials degrade on exposure to the environment.

Another major deficiency in the current approach to design is the failure to define what constitutes the end of the design life.

Service Life

Service Life (of a building component or material) is the period of time after installation (or in the case of concrete, placement) during which all the properties exceed the minimum acceptable value when routinely maintained. Three types of service life's have been defined (Summerville 1986).

2. Technical Service Life is the time in service until a defined unacceptable state is reached, such as spalling of concrete, safety level below acceptable, or failure of elements.
3. Functional Service Life is the time in service until the structure no longer fulfils the functional requirements
4. Economic Service Life is the time in service until replacement of the structure (or part of it) is economically more advantageous than keeping it in service.

To predict Service Life of existing structures, information is required on the present condition of concrete, rates of degradation, past and future loading and a definition of end of life. Based on remaining life predictions, economic decisions can be made on whether or not a structure should be repaired, rehabilitated or replaced.

End of life should therefore be defined and could include the following:

2. Structural safety is unacceptable due to material degradation or exceeding the design load carrying capacity.
3. Severe material degradation such as corrosion of reinforcement initiated by depth of carbonation exceeding reinforcement depth or chloride levels above a threshold.
4. Maintenance requirements exceed available resources.
5. Aesthetics become unacceptable.
6. Functional capacity of the structure is no longer sufficient for a demand.

For corrosion of reinforcement in concrete structures the limit states illustrated in Figure 1 could be used depending on the nature and location of the structure and the criticality of the element or part of the element being considered.

Probability Based Durability Design

To take the variabilities associated with degradation into consideration a probabilistic approach to durability design similar to that used in Structural Design is being developed [9]. This must take into consideration not only the variability of the properties of concrete which influence durability but also the inherent variability of the exposure condition or environmental loading on the structure.

The proposed approach for durability design is similar to that used in structural design. In its simplest form this is presented as a limit state function of the form;

$$R(t) - S(t) >= 0$$

Where R(t) is the resistance and S(t) is the load and both are assumed to be time dependent. For structural design it is usual to assume that the strength remains constant and that the loads, even if fluctuating, can be characterized by a single value. In each case partial safety factors are applied to take account of variability and uncertainties, leading to design values.

Durability is by definition, time dependent and hence these simplifying assumptions cannot be made. Furthermore, there may be several serviceability limit states. Siemes and Rostam [10] have described two approaches to durability based on the 'intended service period design' and the lifetime design'. These are illustrated in Figure 2

To take forward such approaches in the Malaysian context there is an urgent need to gather data and assess these systematically so that target (Dc) values for concrete in the tropical environment can be developed. An international standard on Design Life, ISO 15826 is now being formulated where life cycle approaches are being developed as guidance to service life planning in buildings. The principals of this standard are also applicable to other types of infrastructure. Key to the implementation of this standard is the compilation, assessment and review of available data and identifying gaps in data requirements.

MODULAR CONSTRUCTION AND STANDARDISATION

Prior to the 1997 downturn there was a clear move in the industry to increase productivity to achieve greater construction volumes. This meant considering industrialization of the construction process in all aspects. The need for a greater emphasis to be placed on the creation of systems, processes and approaches that are advanced and capable of propelling the construction Industry to becoming highly industrialized was clearly on the cards. The term industrialization covers all measures needed to enable the industry to work more like the manufacturing sector. This means the introduction not only of new materials and construction techniques, the use of dry processes, increased mechanization of site processes and the manufacture of large components under factory conditions of production and quality control; but also improved management techniques, the correlation of design and production, improved control of the selection and delivery of materials, and better organization of operations on site. It is interesting to note that in the 60's when system building was first applied earnestly in the United Kingdom [11], the competition acted as a spur to the traditional side of the industry into greater efficiency. The lessons learnt in developing higher management skills and planning techniques had infiltrated into this side of the industry. This is a clear indication that much can be done to improve the present conventional construction methods relying on in situ concrete and formwork systems to achieve greater efficiencies. Considering the individual nature of the construction projects, the need to enhance and develop this traditional side of the industry could be the most effective way to improve productivity. Such possibilities as using prefabricated reinforcement cages and precast concrete formwork, as part of the final structure needs to be pursued as part of the process of developing efficiency in traditional construction.

In the case of housing provision for instance the 7th Malaysia plan (1996 to 2000) targeted the construction of 800,000 housing units. Of this 740,000 units were required to meet the growing population characterized by a declining household size and the balance of 60,000 units as replacements. Of the total target, the private sector was expected to deliver 570,000 housing units or 71%. This was a much higher target than that achieved under the 6th Malaysia plan (1991-95) when the private sector met the low-cost housing target by building 217,000 units. Industrialized housing can go some way to providing these needs on a timely and cost effective manner.

At present it is normal for each structure to be designed as a one off. Whilst this leads to structures with varied appearances, tailored to the requirements of the individual clients it also has many drawbacks. More rationalization and standardization within the industry can have several positive effects:

2. Easier application of manufacturing processes to fabrication; reducing site work, improving quality (hence durability), health and safety and efficiency. Reduction in the learning phase for the work force on each project
3. Reduction in the learning phase for suppliers on each project improving the chances of the correct products being supplied
4. Further possibilities for mechanization of construction processes reducing site staff and improving efficiency
5. Rationalization of communications, particularly IT leading to better relationships within the construction team
6. Reduction in Labour resources with increased efficiency

This increased rationalization / standardization does not necessarily have to result in uniformity of appearance, rather it should be used to provide customized solutions using standard components. The implementation of industrialized building systems requires a multi-disciplinary approach where focus on issues such as modular dimensions, is within the purview of the designer / consultant while the production and delivery of pre-fabricated panels is the purview of the manufacturer and requires mechanical / production engineering skills and knowledge of plant and process technology. Care however needs to be exercised in the wholesale adoption of system pre-fabricated building. There needs to be some form of appraisal of new systems, either through a central agency or appropriate technical centers, if Malaysia is to avoid the pitfalls of using poorly developed building systems which are inappropriate for the local tropical environment.

For any successful development of systems building there needs to be economies of scale. High capital investments and overheads of factory, plant and transport make it essential for system building to have continuity of work load if it is to operate at its most efficient and be economic. In this context a review needs to be made of existing system building approaches in the country and the selection of the least 3-5 systems technologies available as a basis for standardization. The major difficulties during the implementation phase are likely to be establishing adequate quality control of units, the accuracy of placement of units in position in the building and the efficiency of site management. The greater speed of erection of system building and the reduced time between operations requires a higher quality of performance from site management than traditional methods. All of these require a rigorous skills development program to be implemented. As concrete is the primary material used in pre-casting the ready mix industry has a key role to play in this development.

TRAINING & SKILLS DEVELOPMENT

The need for training at all levels within the construction industry although well recognized and often discussed, remains largely unfulfilled. The lack of experience of clients and designers heavily influences the design and construction process. Designers and contractors must have a good understanding of the construction process while supervisors, clerk of works and operatives who actually handle the day to day on site issues are the critical link to the delivery of any project. Many clients have limited experience of the design and construction process. Designers' understanding of the construction process is often limited to their personal experience. Training and feed back needs to provide them with wider understanding of the process. The need for a well trained workforce is without doubt an essential ingredient to achieving a vision of a modern, well organized construction industry which will be the pride of the nation. The productivity gains that can be achieved with a skilled work force can be clearly identified and the resultant reduction in the incidence and level of construction defects. Avoiding the risk of rework and the resulting extra costs could make operative training and qualification a sound investment.

The construction industry in Malaysia has developed in leaps and bounds despite the complete lack of any recognizable skills development program. However there is much evidence to suggest that in fact this has been achieved only by over manning and therefore unproductive use of resources. In 1990 the industry employed 250,000 persons with about 30% of the workforce directly involved in the residential construction market. This figure had increased to >370,000 in 1993 and was estimated to be approximately 750,000 in 1997 prior to the economic crises. It was estimated then that some 350,000 of these workers were foreign. [10] Current figures have not been published but a significant proportion of workers both foreign and local left the industry over the last 5 years due to the shrinking of work in this sector. Nevertheless the construction industry remains an important sector of the economy for employment.

As a significant proportion of the unskilled and semi-skilled construction workers are foreign, there is an urgent requirement to address the human resourcing needs of the construction sector. The use of local resources, as an alternative replacement, as several thousands school leavers enter the labor market each year after completing their secondary education needs urgent attention. In order to encourage participation in construction, several key areas of the industry will need to be improved so that working conditions and benefits equivalent to other industries are realized.

Training needs to be implemented in a systematic way with progress assessed and certified with the development of an accreditation system. This should happen across the board but should involve the transfer of both basic knowledge and the latest developments, customized to the local environment and needs. Much needs to be done to tropicalize available information for application locally and develop Malaysia as a center of innovation in this regard for the tropical belt countries.

The human resource development of Malaysians needs to be stepped up to fill the vacuum particularly in the trades skill. There is an urgent need to match resources with opportunities so that the construction sector retains a capacity to continue the delivery mechanisms in construction and contribute to growth which is inevitable as the economy grows again. The National Ready Mix Concrete Association together with the American Concrete Institute (KL Chapter) have made some good progress in this regard by running basic level concrete technology courses for concrete technicians. The Construction Industry Development Board (CIDB) is best placed to spearhead a more systematic development of practical skills training in association with trade organizations and specialist in the field. The urgency of this cannot be overemphasized.

CONCLUDING REMARKS

The Concrete industry has made significant strides in the last decade but had to bear a significant downturn following the asian currency crisis in 1997. With the potential for growth in the construction sector again a reality it is imperative that the ready mix industry gears itself up to meet future challenges. These include overcoming low productivity, a lack of skilled labour and meeting the increasing need for structures with low life cycle costs. The paper has highlighted the possible technical options which can be considered to overcome these issues. This includes the use of SCC, the greater use of HPC, the development of probabilistic approaches to design life, wider implementation of pre-casting techniques and a more concerted effort in Training.

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TABLE 1: RANGE OF MIX CONSTITUENTS

Constituents	By Volume	By Weight (kg/m³of concrete)
Coarse aggregate	30-34% concrete volume (32%)	750 - 920
Fine aggregate	40-50% of mortar volume (47%)	710 – 900
Powder	-	450 – 600 (500)
Water	150-200 I/m3 of concrete (180 I/m³)	150 – 200
Paste	34-40% of concrete volume (35%)	-

TABLE 2: TEST AND SUGGESTED CONSTANTS FOR SCC

Test	Properties	Suggested limits
Slump flow	Filling ability; visual observation of segregation resistance	Diameter > 650mm T50 < seconds
L – box	Filling ablity; passability; visual observation of segregation resistance	Blocking ratio > 0.8
U – box	Filling ability; passability	Filling height > 300mm
V n- funnel	Passability; resistance	Flow time: 10 – 20 second
Surface settlement	Segregation resistance	Surface settlement < 0.50%
Penetration test	Segregation resistance	Penetration depth < 8mm
Segregation test	Segregation resistance (hardened concrete)	Segregation coeff. < 7% for 700mm column

TABLE 3: COMPARISION OF HIGH WORKABILITY FLOWING CONCRETE VS SELF-COMPACTING CONCRETE

	Flowing concrete	Self-Compacting concrete
Slump (mm)	> 200	Not applicable
Flow table diameter (mm)	500 – 650	Not applicable
Slump flow diameter (mm)	-	650 ± 25
Test method subjected to	Drop test	Free flow
Compaction	Moderate vibration	No vibration
Admixture	Melamine / Naphthalene Sulphonates Superplasticizers	Modified polycarboxylic Ethers / Viscosity Modifying Agents Hyperplasticizers

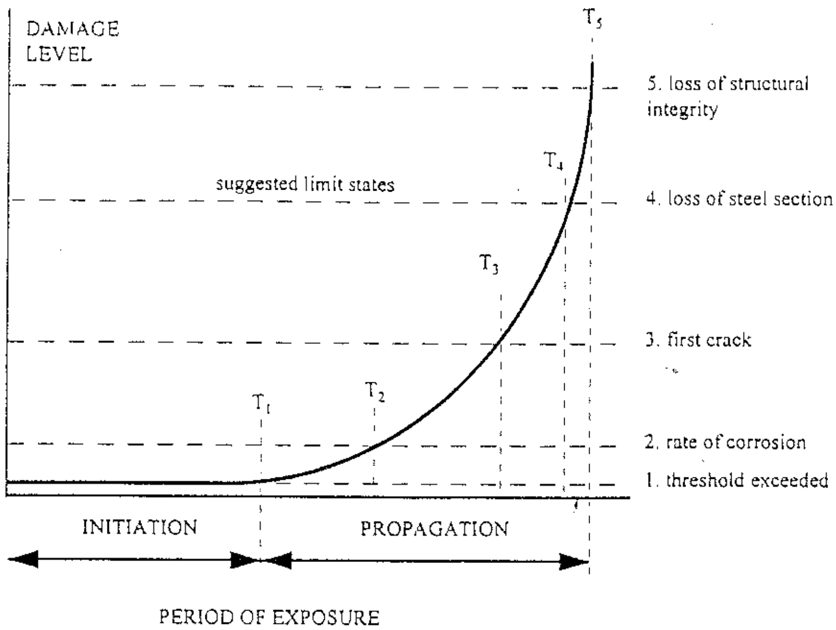

FIGURE 1 The General Deterioration Modal and Suggested Serviceability Limit States for Reinforced Concrete.

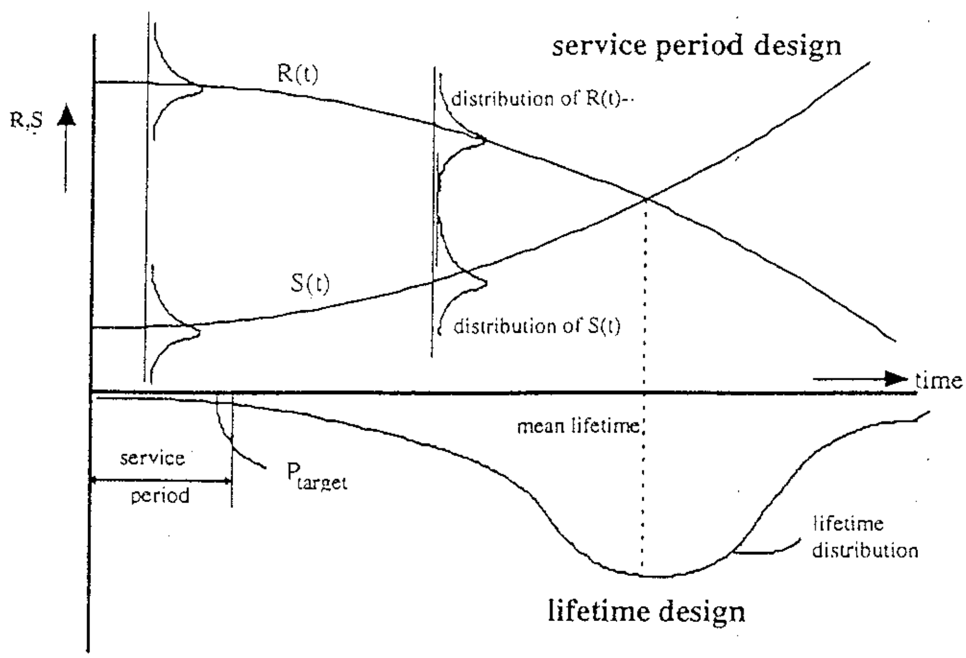

FIGURE 2 Service Period Design and Lifetime Design.