Plenary Session 3: Impact of structures on the environment

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Plenary Session 3

Impact of Structures on the Environment

Impact des structures sur l'environnement

Auswirkungen von Bauwerken auf die Umwelt

Organizer: Jean-Claude Badoux, Switzerland

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Fundamental Considerations on the Aesthetics of Bridges

Considérations fondamentales sur l'esthétique des ponts

Grundlegendes zur Brückenästhetik

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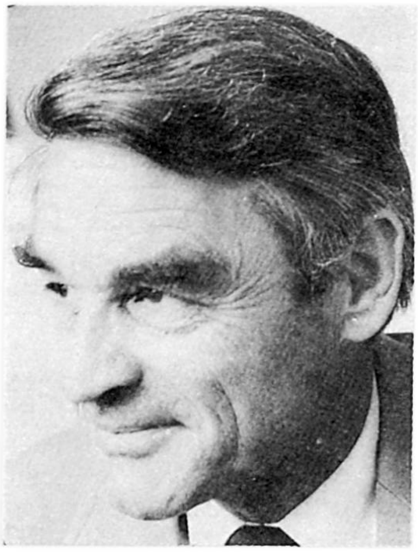

SUMMARY
Bridges are special among works of engineering in that their visual form is determined by a combination of technical and cultural considerations. This paper presents criteria, which reflect this fundamental characteristic of bridges, for assessing aesthetic impact. In addition, it proposes measures to improve the general standard of visual quality in bridges through reforms in education, design practice, and administration of projects.

RÉSUMÉ
Les ponts sont des ouvrages particuliers conçus par des ingénieurs et dont la forme reflète non seulement des aspects techniques mais encore culturels. Le présent article fournit quelques critères que l'ingénieur spécialiste des ponts devrait prendre en considération lors du projet, quant à l'aspect esthétique des ouvrages. Toutefois, outre une amélioration générale de la conception de ces constructions, cela exigerait égalemeent des modifications dans la formation, la pratique des projets et l'adjudication des marchés.

ZUSAMMENFASSUNG
Brücken sind besondere Ingenieurprodukte, bei denen die Form neben technischen auch kulturelle Aspekte wiederspiegelt. Im vorliegenden Beitrag werden einige Kriterien dargestellt, die der Brückeningenieur beim Entwurf im Hinblick auf das Erscheinungsbild des Bauwerkes beachten sollte. Darüber hinaus würde aber eine generelle Verbesserung der Brückengestalttung auch Änderungen in der Ausbildung, der Entwurfspraxis und der Auftragsvergabe erfordern.

Introduction

Works of civil engineering are, first and foremost, objects with clear practical purpose. They serve the needs of society by facilitating transportation, generation of energy, supply of clean water, and disposal of waste. To be effective, they must fulfill their specified functions and be safe and serviceable. Because the construction and operation of large civil works usually entail large expenditures of public funds, it is of primary importance to keep the ratio of costs to benefits as low as possible throughout the life of the project. This is achieved by civil engineers through consistent application of the most up-to-date technical knowledge in the design and construction of large projects.

As a result, the visual form of civil engineering structures follows directly from their function and the current state of technology. Purely visual criteria, if considered at all, are limited to the embellishment of minor details.

Works of architecture, on the other hand, must satisfy functional and cultural requirements. Because cultural costs and benefits cannot easily be expressed in monetary terms, it is rarely possible to establish an unequivocal ratio of costs to benefits for architectural projects. Cultural aspects are expressed through visual form, which is consciously and carefully designed. Technology is but one of many means at the disposal of the architect to create the desired visual effect. The costs of fulfilling cultural requirements through appearance are often substantial.

In the context of visual form, bridges occupy a special place between engineering and architecture. Bridges are undeniably practical structures, built to facilitate the movement of people and goods across obstacles. As with other public works, economy has dictated that bridges be designed and built using the most advanced technology available. This has resulted in an intimate link between technological developments and the appearance of bridges and clearly places bridges within the domain of engineers rather than architects.

Bridges are also objects of prominence in our environment. Their size and number have made them integral parts of most urban and many rural landscapes. Bridges thus hold great potential for enhancing quality of life through proper design of their visual form. and in the hands of gifted designers, they can even be vehicles for artistic expression. Aesthetically pleasing bridges do not follow automatically from technical considerations, however. Even when requirements regarding safety, function, and economy are satisfied, appearance may still be unsatisfactory. The raw form resulting from technical considerations can and must always be refined through conscious aesthetic choices.

The importance of aesthetics has always been recognized by great bridge designers, whose professional lives have been distinguished by ever-increasing concern for the appearance of their structures. This intimate relation between aesthetics and technology may be one reason for the fascination that bridges have always held for engineer and layman alike.

Vocabulary and Criteria

Traditional vocabulary and criteria are often ill-suited for the discussion and evaluation of the aesthetics of bridges. For example, abstract concepts such as the golden section are of little value, since they do not account for the relation between technical and cultural aspects of design. It is preferable to develop a new vocabulary and new criteria based on observations of existing bridges.

As a first step, it is necessary to consider both the relation of bridges to their environment and bridges as independent entities. Bridges are not only elements of a larger landscape but are also artifacts of the historical era they were built in. Environment is thus considered here in a broader sense and can be broken down into two spatial components:

1. Natural landscape and topography

2. Man-made landscape, including existing structures

and two temporal components:

1. History and tradition
2. Contemporary intellectual climate and state of development of technology

Designers can integrate bridges into the environment by an appropriate choice of structural system and of scale (fig. 1). Careful consideration must be given to the relative importance of the previously mentioned components of environment. Although topography and state of development of technology normally govern, higher priority must often be given to existing structures and tradition, especially in urban areas. Structural dimensions–in particular length of spans and height of piers and towers–must be carefully chosen so as not to clash with topography and existing structures.

The design of bridges as independent entities can be characterized in terms of the following criteria:

1. Visual expression of efficiency
2. Order and unity
3. Artistic shaping

The purely technical concept of efficiency, i.e. maximum effect with minimum consumption of materials, is visually expressed through slenderness and transparency. Slenderness depends primarily on the form of the superstructure, in particular on the ratio of depth to visible length of the girder. Transparency is achieved through proper design of piers and arrangement of span lengths.

Order and unity are achieved through clear organization of the structural system and through coherent cross-sectional shapes (fig. 2). Discontinuities in form and in the principal dimensions (depth and width) should be avoided whenever possible. For example, precast girders should not be used in one portion of a bridge when cast-in-place box girders are used in another. The discontinuous cross-section of hammerhead piers can be particularly disturbing unless the transition from pier to head is carefully shaped.

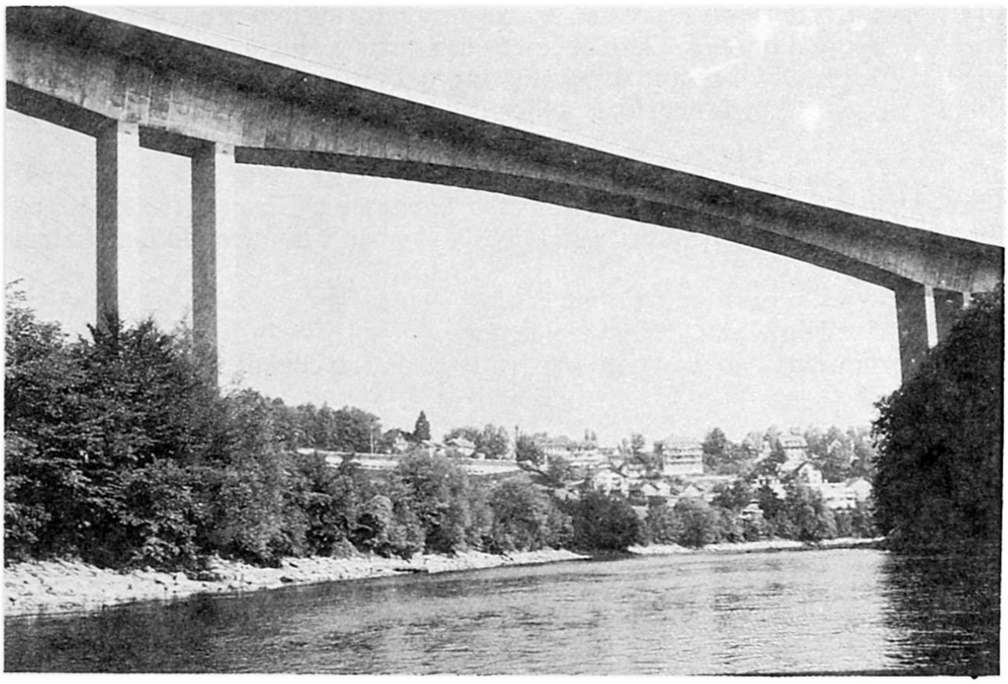

Figure 1
Suitably chosen bridge height and span lengths help to integrate bridges into their environment

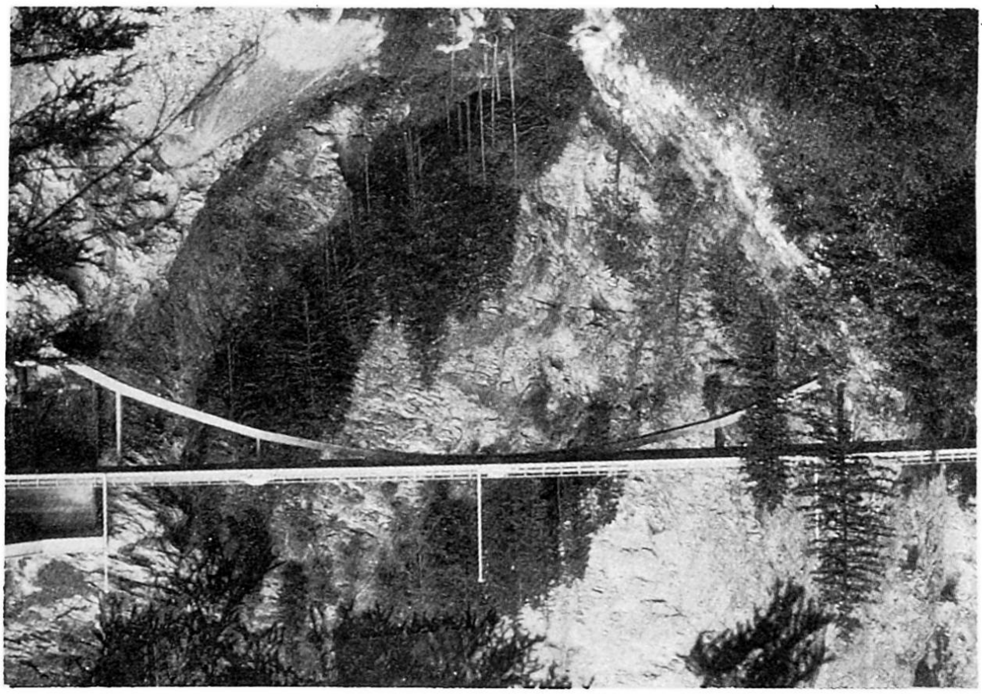

Figure 2
Mutually consistent cross-sections for arch, spandrel columns, and girder give this bridge a high degree of order and unity

Artistic shaping can be achieved through the following methods:

1. Visual expression of the flow of forces
2. Members and cross-sections that minimize stress
3. Light and shadow effects
4. Non-structural components and ornamentation

The flow of forces is often well expressed by the structural system itself. It is particularly evident in arch and cable-supported bridges. Flow of forces can also be articulated by proper three dimensional shaping, which is especially suitable for expressing stability transverse to the axis of the bridge, and by variation in cross-section dimensions, which can be used to emphasize the magnitude of stress in members.

Cross-sectional shapes and members that minimize stress are particularly suited for piers, towers, and arches. The resulting form often agrees well with the layman's intuitive notion of elegance.

Mechanized methods of construction often produce temporary states of stress that are different from those in the completed structure. The associated temporary flow of forces is best left unexpressed in the structure. It is preferable to deal with high stresses during construction using temporary measures (fig. 3).

Light and shadow effects, non-structural elements, and ornamentation have no direct relation to the technical aspects of bridges. These measures are best left to designers with well developed artistic ability.

The appearance of bridges can only be properly evaluated in three dimensions, using computer graphics or large-scale models. All possible points of view must be considered. Two-dimensional drawings are normally inadequate for this purpose, even for designers with good three-dimensional imagination (fig. 4).

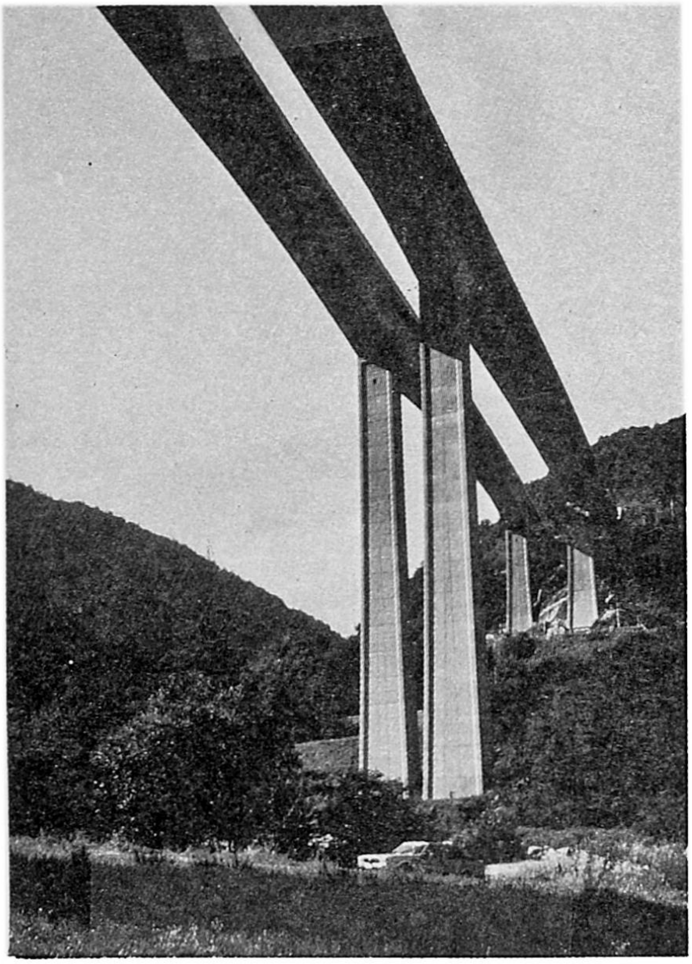

Figure 3
The cross-section and form of the piers are visual expressions of the flow of forces. The somewhat massive dimensions of the cross-section were required to resist critical loads occurring during construction.

Improving Bridge Aesthetics

The evolution of structural systems for bridges has, in recent decades, resulted in several commonly built types. In most parts of the world, one or more of these systems have been established as standards and far outnumber all other types. Unfortunately, the design of most of these standards has been limited to questions of safety, serviceability, and economy, with little or no attention given to aesthetics. This is above all due to the following reasons:

1. Neglect of the visual aspects of design in the education of engineers
2. Excessive emphasis on the analytical aspects of design in engineering practice
3. Insufficient support for aesthetic excellence from the owners of bridges

Structural engineering is based on the natural sciences. As a result, mathematics, mechanics, physics, and chemistry take up a large portion of the education of structural engineers. The actual specialist training normally consists of fundamental principles of technology and results of recent research. Little time is left for presenting a unified approach to design, in which both technology and aesthetics are considered. Unfortunately, there is a lack of motivation in academic circles to increase emphasis on design, possibly because few professors have any practical experience in this area.

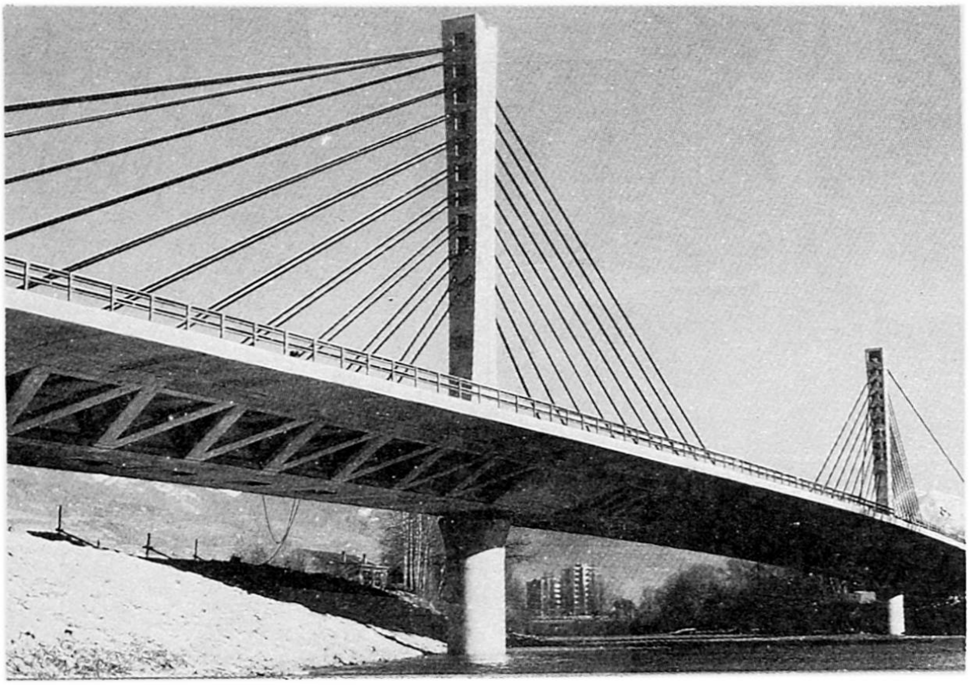

Figure 4
This otherwise elegant bridge has several small deficiencies: different shapes for pier and tower cross-sections, lack of visual order in the arrangement of cables, and a widening of the tower (in the longitudinal direction) that is unnecessary and complicated. Closer attention to the above-mentioned criteria would have helped to eliminate these defects.

As a result, high school graduates who are interested in construction can be divided into two groups: only those who have talent in the natural sciences choose civil engineering, while those who have creative and artistic talent usually choose architecture. This situation can only be changed by a thorough reorganization of the structural engineering curriculum, by which both natural sciences and design principles are firmly enshrined as equal partners.

After the Second World War, research in civil engineering increased dramatically and became more specialized. This development, in itself positive, led unfortunately to design standards and codes of increasing size and complexity, written by committees of specialists who would never themselves use these documents. As a result, many practising engineers find it difficult to assimilate new technical developments and can no longer distinguish between what is important and what is not. They therefore limit themselves to tried and true standard designs. Their entire attention is devoted to the prescribed treatment of specific technical problems, rather than the application of the practically unlimited technological possibilities to the creative design of innovative and elegant structures.

Roughly 90 percent of the practical problems confronting structural engineers can solved reliably and accurately with simple means. The scope of codes and standards should therefore be limited to fundamental principles and typical applications, so as not to constrain creativity and innovation by forcing engineers towards complex analyses. Proper preliminary design has proven to be far more important than exact calculations in achieving economy and elegance.

The owner and the engineers who represent him have a decisive influence on the appearance of structures. Many owners lack the necessary aesthetic sensibility and are often unwilling to provide the necessary political, administrative, or financial support for elegant projects. Faced with this situation, most engineers are reluctant to invest the additional time and money required to obtain a more aesthetically pleasing solution.

Design competitions hold promise for increasing the visual quality of bridges. They promote fruitful cooperation between owner, design engineer, and lay members of the community. The success of competitions depends primarily on the selection of a competent jury, whose members are committed to the ideal of quality in bridge design and who fully understand the interplay between technology and visual form. In addition, the owner must insist on the highest aesthetic standards and must be prepared, if necessary, to request major modifications of the winning project or to reject it altogether.

There is no lack of examples of elegant bridges designed by structural engineers without any assistance of architects. This does not imply, however, that architects may not participate in bridge design. Engineers should not ignore the special abilities of architects not only regarding proportion and form, but also in the area of urban design and planning. Fruitful cooperation, however, is only possible when both professions have a proper understanding of the fundamental principles underlying their counterparts' profession. Architects who have no experience with bridges and who do not understand structural systems, flow of forces, methods of construction, and costs are of little help to engineers. They cannot contribute much more than insignificant cosmetic embellishment.

Aesthetics and Economy

Aesthetics and economy are not mutually independent. It is false to infer, however, that the most economical bridge is necessarily the most elegant one. This proposition is nothing more than a cheap excuse for engineers who would rather save the effort required for visual design and for owners who put little value on the appearance of their structures.

Since cost constraints are usually severe, economy must normally be given primary consideration. Economy may be subordinated to elegance only in exceptional cases, for instance bridges that have special symbolic roles in cities or primarily cultural significance. Genuine bridges are neither works of sculpture nor of architecture that by happy coincidence can also be used to carry traffic.

Elegant structures have their price. Impressive results can be obtained, however, with increases in construction costs of only 10 percent beyond the least expensive solution. Increases of more than 10 percent are therefore rarely necessary. Many of the previously mentioned aesthetic criteria can be achieved at little or no additional cost. Structures that are in scale with their surrounding topography, for example, are always economical. Slenderness, transparency, order, and unity also enhance economy. Added costs can result, however, for bridges that must be integrated into the human components of environment or when extensive artistic shaping is desired. The additional costs associated with artistic shaping are only due to the added complexity of formwork, which amounts to at most 2 percent of total construction cost. As a general rule, simpler and more economical forms for structural components work out better than complicated and expensive ones.

Concluding Remarks

Elegance must be allowed to take its rightful place alongside safety, serviceability, and economy as legitimate objectives of bridge design. A single elegant bridge creates more sensation than a dozen technically correct bridges. For this reason, every major structural engineering congress has rightfully dedicated important sessions to aesthetics in bridge design. Lectures alone, however, are not enough. Changes must be made in engineering education and practice, in codes and standards, and in the attitudes of owners of bridges. Elegant bridges need not be much more expensive than conventional structures. Structural engineering art can be regarded as a search for the best combination of economy and elegance.

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Environmental Problems Related to Dams in India

Problèmes écologiques créés par les barrages en Inde

Umweltprobleme indischer Talsperren

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SUMMARY
Dams are key structures in water resource projects which have contributed immensely in the development of the Indian economy. However, the construction of dams and their subsequent operation have in many cases resulted in negative environmental impacts which had to be controlled to maintain environmental equilibrium. The article discusses certain important issues concerning sizing of low level outlets in dams for evacuation, conducting dam failure analysis and seismic resistant design of dams which are being given due importance from the environmental point of view.

RÉSUMÉ
Les barrages représentent des ouvrages ayant eu une grande importance dans le développement de l'économie indienne. Cependant, aussi bien leur construction que leur fonctionnement ont eu bien souvent des conséquences fatales sur l'environnement; il a fallu revoir et reprendre la situation en main pour en assurer l'équilibre écologique. Sous l'angle de la protection de l'environnement, l'article développe certains points cruciaux relatifs à la section des orifices de décharge prévus pour la vidange de la retenue, à l'analyse du point de rupture des barrages et au calcul de leur résistance aux secousses sismiques.

ZUSAMMENFASSUNG
Talsperren sind von zentraler Bedeutung für Wasserwirtschaftsprojekte, die gewaltig zum Aufschwung der indischen Ökonomie beigetragen haben. Ihr Bau und Betrieb hatten jedoch in vielen Fällen negative Folgen auf die Umwelt, die man zur Wahrung des ökologischen Gleichgewichts in den Griff bekommen musste. Der Beitrag diskutiert als wichtige Punkte die Grösse der Grundablässe zwecks Leerung sowie Untersuchungen der Breschenbildung und der Erdbebensicherheit unter dem Blickwinkel des Umweltschutzes.

1. INTRODUCTION

The development of the Indian economy and the process of its industrialisation has been dependent upon the utilisation of the country's water resources. The demand for enhancing the agricultural produce through irrigation and to provide power to the industries have resulted in the construction of water resource projects and their importance in this respect can be gauged from the fact that from a mere 250 such projects before independence, they have grown to about 2600 by now and many more are presently under construction. Within water resource projects; dams are key structures placed at suitable location across rivers for impounding reservoirs with facilities for controlled release of water from the reservoir for the purpose of irrigation, hydropower, flood control, navigation, domestic and industrial water supply etc. Whereas dams have been responsible for the all round development of the country by fulfilling the purposes mentioned above, their construction and subsequent operation have led to certain negative environmental impact, which unless managed to maintain environmental equilibrium could lead to erosion of benefits. The problems need to be identified in detail for undertaking remedial action. This article describes specific problems related to dams in India and elaborates only on those technical issues that are presently receiving attention.

2. ENVIRONMENTAL PROBLEMS

The environmental problems created by dams in India are the same as those reported globally inkind, though their intensity may differ. These relate to the effect of submergence which is quite huge in a thickly populated country like India requiring enormous effort & resources for the rehabilitation of displaced humans, animals, birds and aquatic tauna. A culturally rich country like India had often to relocate its archaeological and anthropological relics to preserve its cultural identity. The near stagnant water in the reservoir and the marginal water systems around the dam turned into breeding ground for the insects and flies that carried many dreaded diseases which had to be combated. The entry of agriculture, domestic and industrial wastes having plant nutrient properties into the reservoir led to eutrophication and degradation of water quality which also had to be combated. Aforestation has been carried out specially along the rim of large reservoirs to prevent sliding of the embankment into the reservoir and reduce its life through an increased sediment load.

In addition to the general issues mentioned above, engineers in India engaged in the field of water resources are presently concerned with certain purely technical issues to prevent damaging the environment on account of the construction, design and operation of dams. These issues relate to provision of low level outlets in the dam to enable evacuation of the reservoir during its maiden filling and at times of distress in the dam which may lead to its collapse. The second issue concerns conducting dam break analysis for all major dams to determine the arrival time of the flood wave and the inundation area in the event of a dam failure to enable preparation of emergency management plans to reduce loss of life and property. The third problem concerns guidelines for conducting investigations and application of advanced analytical techniques for conducting seismic resistant design of dams for dams located in seismic zones, to have an assurance on their safe performance during earthquakes and to protect the environment from the disaster that could occur in the event of their failure during earthquakes.

3. SPECIFIC ENVIRONMENT RELATED PROBLEMS

3.1 Sizing low level outlets for evacuation

Evacuation facilities by the provision of low level outlets in dams impounding reservoirs are essential to enable evacuation of the reservoir for controlling the reservoir levels during the critical period of maiden filling and also for evacuating the reservoir when the dam is in distress with the purpose of preventing its sudden failure and cause enormous environmental degradation. Low level outlets are also utilised for inspection and maintenance of those areas of the dam that generally remain covered by the reservoir. In general; the designers take a lot of care for designing surplussing arrangements above the crest of spillway by appropriately designing spillway gates, but more often than not, adequate care is not bestowed on the location and sizing of low level outlets.

Certain criteria and guidelines were worked out in 1986 in the Central Water Commission in India for sizing low level outlets for evacuating storage reservoirs based on the requirements of initial reservoir filling and depletion of the same during distress.

Low level outlets for emergency drawdown during initial filling should be located at the lowest possible level and should have discharge capacity sufficient to maintain reservoir filling rate as specified and to hold reservoir level reasonably constant for elevations approximately above fifty percent of the hydraulic height. Inflows into the reservoir should be assumed as the average of the mean monthly inflow in the selected filling period and reasonable frequency flood.

The initial filling of the reservoir is done in stages. The criteria is more stringent for embankment dams as compared to gravity dams. The first stage consists of filling the reservoir upto the Minimum Drawdown Level (MDDL). This filling can be done without restraint for all dams. The second stage consists of filling the reservoir from MDDL to crest of spillway. The rate of filling should not exceed 3 metres per fortnight and for embankment dams should be temporarily stopped at 50% elevation from MDDL to crest of spillway in order to assess the behaviour of the structure, and take a decision about further storage. Further filling is continued in gradual sub-stages of 2 to 3 metres per fortnight upto the crest of the spillway. For gravity dams, the reservoir above MDDL should be gradually built up at a rate not exceeding 3 metres per fortnight and held at the level of crest of spillway in order to assess the behaviour of the structure and to decide on further storage. The third stage consists of filling above crest of spillway to Full Reservoir Level (FRL). The rate of reservoir filling in this zone is not more than 30 cm in 48 hours. The reservoir should be temporarily held at half the height between crest of spillway and FRL for sufficient time for monitoring and evaluation of the performance of the dam and to take a decision for further storage. Further filling up to FRL is continued at the same rate. The filling criteria is the same for both gravity and embankment dams in this stage. For gravity dams having high earthen flanks, the procedure suggested for embankment dam applies.

Sizing of low level outlets for evacuation of the reservoir is dependent on the reservoir volume and evacuation time specified for the reservoir. Guidelines for evacuation time generally take into account the hazard potential of the downstream population and installations along with the risk potential of the dam. For evacuating storage reservoirs and sizing low level outlets, three categories have been suggested as below: These assume a general balance between hazard and risk and could be adjusted on the basis of detailed site specific studies.

Sl. No.	Depth of Evacuation (from initial pool level)	Degree of hazard or risk (High)	(Significant)	(Low)
		Evacuation time in days		
1.	25%	20	30	50
2.	50%	40	50	70
3.	75%	80	90	100

The above evacuation periods may not be technically feasible for unusually small or large dams.

3.2 Conducting dam break analysis

Dam break analysis in brief describes the scenario in terms of flood wave arrival time and contours of inundated area in the valley downstream of the dam when under the impact of an extreme event (hydrologic or otherwise) the dam collapses. Since the collapse of a dam followed by the uncontrolled release of water could cause unprecedented ecological damage in terms of loss of life, property and degradation of everything coming under the impact of floodwave, guidelines have been prepared to work out inundation maps for various flood frequencies including peak floods coupled with dam break to enable preparation of emergency action plans in order to ensure minimum loss to life and property in the event of a dam failure.

The "Report on Dam Safety Procedures" approved by the Government of India in 1986 suggests preparation of inundation maps for 25 year flood frequency, 50 year flood frequency, routed design flood, probable maximum flood coupled with dam break. Software used for dam break analysis consists of DAMBRK developed by the National Weather Service of USA and MIKE 11 of the Danish Hydraulic Institute, Denmark. Inundation maps for the above conditions have already been prepared for a few large dams under distress and those which have a large density of population and important installations downstream of the dam. In due course inundation maps for all large dams under distress and in the high hazard category will be prepared to undertake mitigation measures against dam failures to ensure minimum negative impact on the environment.

3.3 Seismic resistant design of dams

India is one of those countries in the world where the development of water resources occurred at an accelerated pace after independence i.e. after 1947 resulting in the near exhaustion of ideal sites for dams. Engineers are now compelled to design and construct dams in the Himalayan terrain where the geology is varying and the area is seismically active. Dams have therefore to be designed with special care from seismic considerations to prevent their failure under extreme seismic events and cause an ecological disaster.

Of late, seismic resistant design of dams in India had received a lot of attention through intensive seismotectonic studies of the dam site, preparation of appropriate response spectra, adoption of dynamic analysis for dams by the application of Finite Element Method and by establishment of seismic network in and around the damsite and mounting elaborate seismic monitoring instruments within the dam and its foundation. There is a National Committee on Design Seismic Parameters for Water Resource Projects in India with representation of senior engineers from the field of Water Resources, Meteorology, Seismology, Geophysical Institutes, Geology and the School of Earthquake Engineering who as a single unit are required to examine the seismic aspects of major dams referred to it and render precise advice on the design seismic parameters for the dam and appurtenant structures.

Reservoir Induced Seismicity (RIS) in India is less of a fact and more of a figment of imagination in the minds of freelance environmentalists who are lobbying against building of large dams in India. The existence of RIS has however not been established by observations at seismic network established at major dams in Himalayas like Bhakra (226 m), Pong (133 m), Mangla (138 m), Tarbela (143 m), Pandoh (76 m), all of which lie near the epicentre of the Kangra earthquake of 1905, which had a magnitude of more than 8 on the Richter scale. For monitoring RIS at dam sites located in areas of moderate to high seismic intensity, seismic networks were established at the dam and in areas surrounding the reservoir, and readings analysed regularly.

4. CONCLUSIONS

The present environmental problems in India related to water resource projects is largely due to post independence government sponsored projects depicting the nation's urgency in providing basic necessities to the ever increasing population through rapid economic development, in which little or no consideration was shown for protection of the environment. However, in recent years, there has been a change in the perception of the environment in the exploitation of natural resources for development activities, which is evident in the regulatory measures enacted like the Water Pollution Act, Air Pollution Act and the Environmental Protection Act. These acts however do not encompass issues concerning environmental imbalances created by dam building activity. Certain guidelines on this issue has been embodied in the National Water Policy issued by the Government of India in 1987, which in brief states that in the planning, implementation and operation of water resource projects, the preservation of the quality of environment and the ecological balance should be a primary consideration. In the last decade water resource projects have been approved for construction only after they were cleared from the environmental angle. Of late in March 1990, the Government of India constituted an Environmental Monitoring Committee for ensuring effective implementation of environmental safeguards in irrigation, multi-purpose and flood control projects. The monitoring committee is headed by Member (Water Planning) of the Central Water Commission (CWC) with representatives from the Ministries of Water Resources, Environment and Forests, Agriculture, Welfare, Planning Commission and CWC as members of the Committee.

Due to restriction of space, only technical issues concerning the impact of dams on the environment has been elaborated in this article, and indicates the awareness of water resource engineers towards maintaining environmental equilibrium in a scenario where due to the heavy demand on hydro-power, the compulsion has been to plan construction of large water resource projects in areas of varying geological formation and are seismically active. Time will only tell how successful has been the structural and non-structural plans for these projects in protecting the environment.

The Øresund Bridge-Tunnel. Assessment of the Environmental Impact

La liaison fixe sur l' Öresund. Impact sur l' environment.

Die feste Verbindung über den Öresund. Umweltverträglichkeit

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Per Clausen, born 1945, received his Master of Science degree from the Techinical University of Denmark in 1971. Employed in the construction industry from 1972 till 1978. Since then working for the Road Directorate in Denmark.

Kurt Lykstoft Larsen, born 1946, received his legal education at the Univ. of Copenhagen. Now responsible for questions concerning Danish fixed links in the Ministry of Transport in Denmark.

SUMMARY
Today it is considered very important that before the start of large construction projects a thorough analysis is made of the effects of the construction on the external environment. The environmental investigations normally have to be carried out in several steps, for the actual environmental assessments, which are an important prerequisite for the final decision to go ahead with construction, has to be followed by an environmental optimization in the design stage and by surveillance during and after the construction stage to ensure that the assessments hold good. In the article the bridge-tunnel across the Øresund between Denmark and Sweden is used as an example of construction that has been subject to a careful assessment.

RÉSUMÉ
Aujourd'hui, avant de mettre de grands travaux en chantier, il est important de procéder à des études approfondies de compatibilité avec l' environnement. Ces études sont effectuées par étapes, étant donné que les véritables évaluations environnnementales, dont dépend largement la décision de réaliser les travaux, doivent être suivies d'une optimisation environnementale dans la phase de conception et dans la phase de réalisation. Une phase de surveillance doit suivre pour vérifier le fondement des évaluations. Dans le présent article, le liaison fixe sur le Sund reliant le Danemark à la Suède est donné comme exemple d'une construction dont l'impact sur l'environnement a été très soigneusement étudié.

ZUSAMMENFASSUNG
Vor der Ingangsetzung von grösseren Bauprojekten wird heute grosser Wert auf eine gründliche Prüfung der Umweltverträglichkeit gelegt. Sie wird in der Regel in mehreren Etappen durchgeführt, wobei auf die eigentlichen Umweltbeurteilungen als Voraussetzung für die Entscheidung zum Bau der Anlage in der Planungsphase eine Umweltoptimierung folgen muss. Ebenso ist während und nach der Bauphase festzustellen, ob die Einschätzungen Bestand haben. Im Artikel wird die feste Verbindung über den Öresund zwischen Dänemark und Schweden als ein Bauvorhaben angeführt, das im Hinblick auf die Umwelt beispielhaft untersucht worden ist.

In step with the increasingly accentuated focus in recent years on the importance of environmental aspects, the environmental assessments in respect of major construction works have been carried out with increasing thoroughness. The following is a description of the environmental assessment carried out for the bridge-tunnel across the Øresund (the Sound) between Denmark and Sweden. This is followed by a description of the manner in which the assessments will be followed up in a later stage of the project. /1/ contains a detailed description of the effect of the Øresund bridge-tunnel on the marine environment. The major conclusions from that report are included in this presentation.

The environmental analyses in respect of the Øresund bridge-tunnel were the work of a project group with representatives from all directly involved environmental and construction authorities. The work was successful and fruitful, and it proved important that the environmental authorities both selected the problem areas to be investigated and approved the investigations carried out. One result of this was that questions to the environmental report could be treated by responsible experts who had participated in the preparation and approval of the report.

The bridge-tunnel across the Øresund

For many years a bridge-tunnel between Denmark and Sweden across the Øresund has been planned. Environmental assessments of several proposed constructions have been carried out, most recently in 1990/91 when a very thorough environmental assessment was carried out on two alternative alignments of the fixed link.

On the basis of, inter alia, the environmental report a governmental agreement between Denmark and Sweden was signed on 23 March 1991. The fixed link was adopted by act of law in Sweden in June, and in Denmark the Act was adopted on 14 August 1991. The Agreement was ratified on 24 August 1991.

The link between Denmark and Sweden will consist of a four-lane new motorway and a double-track electrified railway between the cities of Copenhagen in Denmark and Malmø in Sweden. The section on land in Denmark is about 15 km long. The section from coast-to-coast is about 16.2 km. From the Danish coastline it is designed via a 2 km long man-made peninsula, an approximately 2 km long submerged tunnel under the Drogden channel, and then up across a 2.5 km long man-made island. East of the island follows a 2.3 km low-level bridge and 7.4 km long high-level bridge across the Flinterenden and Trindelrenden channels to reach the shore just south of Malmö in Sweden.

The bridge-tunnel and the environment

The environmental propriety of the Øresund bridge-tunnel will be ensured in three steps:

Step 1. Environmental investigation in the spirit of the EC EIA Council Directive (EIA=Environmental Impact Analysis) /2/.

Step 2. Environmental optimization.

Step 3. Environmental surveillance.

Step 1 was almost completed with the issue of /1/, and Step 2 has now been started, after the adoption of the Act. At the same time the considerations about the environmental surveillance under Step 3 will be intensified. The three steps will be described in the following three sections of this paper:

1. Environmental investigations

The following environmental investigations in respect of the Øresund bridge-tunnel have been completed at present:

1.1. Visual character of the fixed link

The envisaged design of the construction was analysed to describe how the fixed link could be given the highest possible aesthetic value.

1.2. Geology and its importance for the construction's environmental effects

Based on existing knowledge a geological model has been constructed which covers conditions both under the land section on the Danish side and under its coast-to-coast section.

The geology of the area raises the following environmental problems:

1.2.1. Groundwater conditions under the land section

Denmark is enormously dependent on her groundwater resources. 98% of the country's total consumption of water is covered by pumped-up groundwater. Water consumption in Copenhagen is at present about 7.8 million m^3, of which about 1.5 million m^3 is extracted from borings placed in Amager near the construction. In Amager the construction has been dug up to 6 m down below ground level, and the groundwater level is at a depth of about 1 m.

The construction will reduce the availability of water. This can be remedied by arranging the necessary lowering of the groundwater in such a manner that polluted water is separated from high quality water and that the high quality water is led to the waterworks.

1.2.2. Earth pollution

The land section will pass a number of areas known for or suspected of containing polluted earth. They are industrial areas and oil/petrol installations.

The polluted earth may present problems in connection with handling and treatment. Moreover, it is expected that the lowering of the groundwater level will activate occurrences of polluted groundwater, which will more rapidly seek down towards the primary groundwater level.

It has been decided that a mapping must be carried out and followed by a detailed examination of all suspect areas near the construction. Through this investigation it must be determined where there will be a need of taking measures to prevent earth pollution.

1.2.3. Earthquake risk for the construction

Denmark is situated in a low-seismic region. There have been no known examples of constructions that have been damaged or destroyed by earthquakes, and there is no tradition of earthquake assessment of planned constructions.

As the Øresund bridge-tunnel will be close to a main fault between the Fenno-Scandinavian bed-rock area and the Danish/German basin it was decided that the earthquake risk for the construction should be assessed. By using the method recommended in Eurocode 8 (draft 1990) it was found that the worst imaginable earthquake within a 300 by 150 km area along the main fault will have its epicentre at a depth of 9 km and a magnitude of 5.3 on the Richter scale. For other reasons the bridge-tunnel will have to be constructed so that it can resist such an earthquake without problems.

1.2.4. Raw material requirements

The construction will need 1.5 million m^3 gravel and 1.1 million m^3 stones for embankments, casings, etc. Another 0.7 mill. m^3 of sand and 1.3 mill. m^3 of gravel are needed for concrete. The gravel for concrete will be extracted from quarries in neighbouring countries or in the small Danish island of Bornholm, and the sand for concrete will probably be extracted from special sand occurrences in or near Bornholm. The other material will be extracted from the sea bottom in the neighbourhood of the construction, and the environmental investigation showed that there are very large amounts of sand/gravel available.

Finally it was estimated that material extracted through digging for the construction can be contained within the man-made island and peninsula. Consequently, no problems are expected in finding space for depositing dug-up materials.

1.3. Historical interest

The sea level in the Øresund area is now a couple of metres higher than in the Stone Age, and in the areas which were then land but are now covered by sea it is possible to make important finds of villages, etc., from the Late Stone Age.

For many centuries the Øresund has been one of the world's busiest waters, and numerous ships have been wrecked in the Sound. We have information about a large number of new and old shipwrecks, but presumably the bottom of the Øresund can disclose many more wrecks whose existence is not known from the files.

A registration has been made of the locations of known Stone Age finds and of wrecks. Test samples have been taken from the sea bottom at especially promising points, and reconnaissance by air has been used to find wrecks.

1.4. Marine environment

In the environmental investigations every effort was made to create a reliable basis for an assessment of the effect of the construction on the marine environment. The investigations, described in detail in /3/, were carried out by simulation in computer models in which all collected data on topography, hydrography and the addition of matter were incorporated.

1.4.1. Marine environment in the Baltic Sea

The distance between the construction area and the Baltic Sea is quite considerable. That none the less the construction can affect the environment in the Baltic Sea is due to the special hydrographic conditions in the area. The Baltic Sea, with its 375,000 km^2 the largest brackish water area in the world, can be viewed as a ligated bay with connection to the North Sea/Kattegat through the 3 belts Lillebælt, Storebælt and Øresund. Some 470 km^3 fresh water annually flows from the rivers into the Baltic Sea, but far larger volumes of water move, depending on weather and wind conditions, northward or southward through the three belts. The water masses pass through Lillebælt-Storebælt-Øresund in the proportions 1:7:3, respectively.

The influence of the construction is amplified by its location on a very important threshold with a water depth of only 7-8 m. North, and often also south, of the threshold the water column is divided into layers with a salt bottom layer and a fresher surface layer. In calm weather the salt bottom layer is prevented by the threshold from reaching the Baltic Sea, and only in cases of sustained southward current does the saltier bottom water get carried across the threshold.

The fixed link will reduce the water-flow through the Baltic Sea by about 3% but the model simulations showed that this has only a very limited effect in the Baltic Sea. The absolute salt content in the surface layers and in the bottom layers in the Bornholm basin will be reduced by only 0.002 and 0.003%, and this should be compared to the natural variation in the same salt content, which is of the order of 0.15% within a period of a few years. Correspondingly, the relative oxygen content will be reduced from 100% to 99.63%.

When digging in the sea bottom it will be possible to avoid these effects entirely, but in order to achieve a true zero-effect more than 11 mill m^3 bottom matter has to be removed from the construction area.

The change in salinity and oxygen might have an influence on flora and fauna. This question will be subject to further analyses which will be initiated in the near future.

1.4.2. Permanent changes in the environment near the construction

The environmental investigations pointed out a number of permanent changes that must be expected in the areas close to the construction. The most important are:

a. The Sound between the man-made island and Saltholm will have a slight tendency to sand up. This must be avoided to prevent foxes and rats to reach Saltholm, where the rich bird-life today depends on the absence of these species.

b. the beach quality north of the man-made peninsula may deteriorate. It will be investigated how a changed coastline can minimize or prevent this problem.

c. A minor worsening of ice conditions in the Drogden in hard winters must be foreseen.

d. Fear has been expressed of increased risk of flooding on South Amager as a consequence of the construction. However, an analysis of this problem showed that the water level increase in the worst case of flooding will be less than 2 cm.

e. Conditions for a small seal colony and a considerable population of moulting swans in the summer months will be poorer.

1.4.3. Temporary changes caused by the construction

A great environmental problem in the building stage may be sediment vanes created by waste from digging processes on the sea bottom. These may destroy or reduce the large common mussel banks, which are basic food for the eiders. The widespread grasswrack water-meadows, spawning and maturing ground for almost all the species of fish that are of interest to the fishing industry, could be damaged. Finally there is a fear that very large occurrences of herring on spawning mission to the Baltic Sea in the spring months will be disturbed by the sediment vanes.

In order to minimize these problems the digging tools for digging on the sea bottom will be tools that can work with a minor waste, and digging will not take place on both sides of Saltholm at the same time in the spring months.

1.5. Noise

A number of assessments have been made of the effect for neighbours of noise from the four-lane motorway and the double-track railway. The assessments have been updated in 1991 from the newest prognoses for traffic across the construction in the year 2010.

A large part of that traffic will be existing traffic which is led from other railways and roads to the construction. Therefore many homes will be relieved of noise while a number of neighbour homes will be exposed to new noise. By placing the construction in a deep excavation an effort has already been made to minimize the noise problems.

1.6. Emissions

Also the emissions from the traffic across the construction have been evaluated, based on the 2010 prognosis, and they were compared with the emissions from traffic without the bridge-tunnel. Assessments were made for the "globally" effective CO_2, and for the more locally problematic CO, NO_x, SO_2, and HC and particles. It has been proved that the emission will be systematically reduced when the fixed link comes into being.

2. Environment optimization

Section 1 of this paper has given a review of the environmental investigations carried out. During the months to come the detailed planning and design will be implemented, and at the same time the environmental work will be continued. The design will be giving the environment maximum consideration, and especially the two main aspects:

The shape of the man-made island and peninsula must be optimized. So the increase in resistance to the water-flow in the Øresund will be down to a minimum, that is the effects in the Baltic Sea, or alternatively the volume of material removed in the compensatory digging, will be small.

To test the amount of waste from the digging tools, test digging must be carried out in the lime underground in the Øresund as support for the choice of optimum digging tools for the work in the hard lime.

3. Surveillance of environment

As mentioned, the environmental authorities have participated actively and in a positive spirit both in the selection of the main aspects of interest and in the work of assessing possible environmental problems. In the optimization stage the environmental influence of the construction will be minimized, but it cannot be entirely avoided that a construction of this size will have both temporary and permanent environmental effects. Therefore a set of rules must be laid down for permissible effects during and after the construction stage, respectively, and a surveillance programme must be prepared to ensure that this set of rules is observed.

REFERENCES.

/1/ The Øresund Environment 1991

/2/ The EC Directive 337, 1985: Environmental Impact Analysis (EIA)

/3/ "Assessments on the Effects of the Øresund Bridge-Tunnel on the Environment" by Kurt Lykstoft, the IABSE Conference, Nyborg, Denmark, May 1991

Impact of the Maritime Ports on the Environment

Impact des ports maritimes sur l'environnement

Umweltbelastung von Seehäfen

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Romeo Ciortan, born 1941, received his civil engineering degree at the Civil Engineering Institute Bucharest, Romania. He was involved in special problems for hydrotechnical construction. Now he is responsible for the design of port construction development, coastal engineering and shipyards.

SUMMARY
Along a great part of its length, the Romanian seashore feels the influence of ports. Fighting with many negative phenomena has imposed steps concerning the ways and means of work operation in order to protect the environment.

RÉSUMÉ
Sur une grande partie de sa longueur, le littoral roumain met en valeur l'influence des ports. La confrontation avec de grands phénomènes négatifs a imposé des mesures concernant la conception et le mode d'exploitation des ouvrages pour la protection de l'environnement.

ZUSAMMENFASSUNG
Ein Grossteil der rumänischen Küste spürt die negativen Folgen der Seehäfen. Die Bekämpfung zahlreicher Emissionen resultierte in Massnahmen; in Konzeption und Betrieb der Anlagen zum Schutz der Umwelt.

1.GENERAL

The world ocean plays an important part to the climate formation, treats a great quantity of oxygen and is very important for life mentaining on the earth. Also very important are the resources constituting food production. The sea and ocean pollution is a major problem and has negative effects on fish production, degrading the shores having negative effects on the people's health. That is why this aspect is in the attention of international forums and of those governments of countries opened to naval ways transports.

As for the Romanian seashore of the Black Sea, on its whole lenght of 245 km we feel the influence of the land seronqly. A specific problem is that of seashore arrangements wich have known an important development during the last two decades.

Thus we have finalized the arrangements of harbours Constantza, Midia and Mangalia as well as the breckwaters and some interior arrangement works of Constantza South harbour in wich the Danube-Black Sea canal outlets.(fig.1)

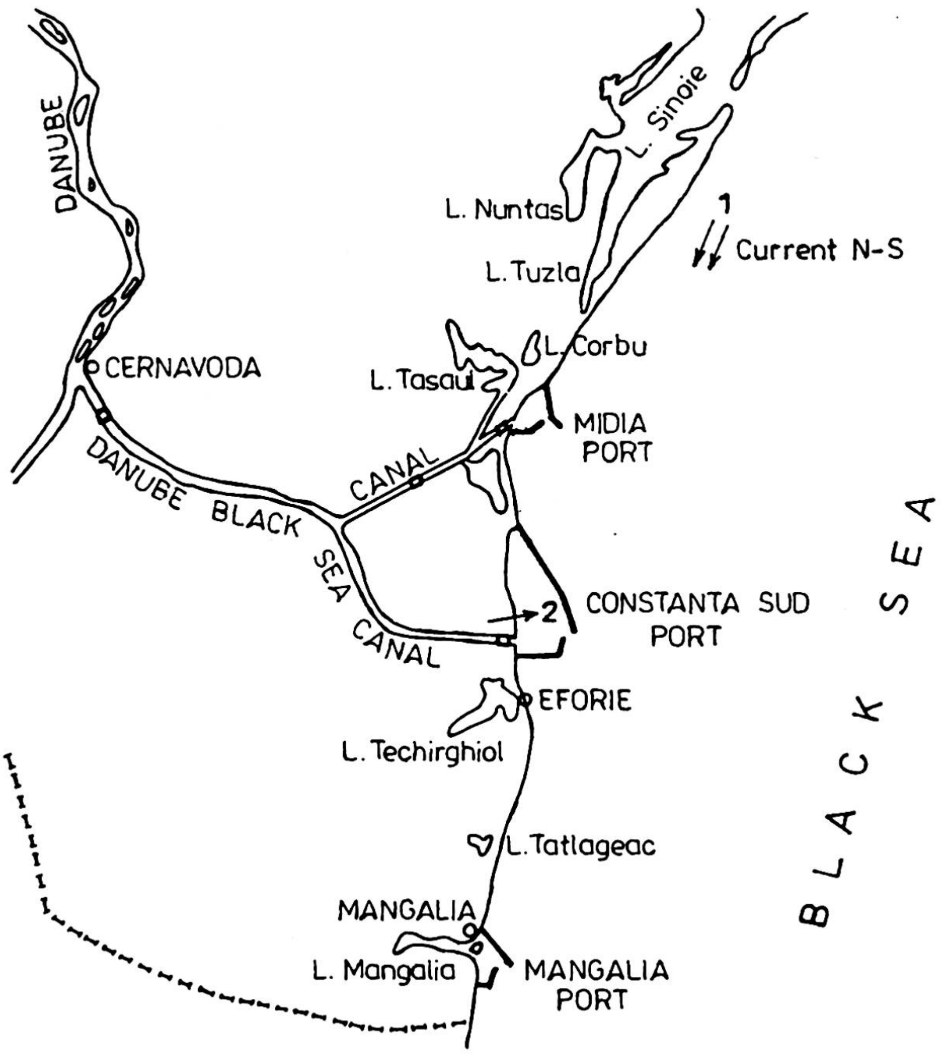


Fig.1 -Ports on the Romanian seashore of the Black Sea
1-current N-S; 2-waste sewerage

The harbour enclosure was achieved whose total surface is of about 4.000 ha with lenghts of panding fronts of about 20.000 m to wich land more than 800 ships respectively 3.500-4000 ships annually with a traffic of over 150.000 t dayly solid and liquid products.
To this activity we must add the one the three shipyards of the three harbours that are being constructed and where a great number of ships are repaired.On this ports over 30.000 employers are working.
The lenght of the seashores has grown from 5.000 m in 1965 to about 17.000 m at present but their effects is felt on a greater area.

2. EFFECT OF HARBOUR WORKS ON THE ENVIRONMENT

The presence of the harbour works is felts under the following aspects:

- disturbance of the alluvial current N-S is interruption where the works avanse into the sea thus obstructing the natural alimentation of the upstream side.
- generalization of litoral corosions as a result of what we have presented.
- influence over sea flowers and animals as a result of the distruction of some mollusks usefull for mentaining the sea animals and the fish production the sea water filtration and the generation of skill sand which is an important feeding source for seashore.
- the penetration of salted water from the sea along the canal affecting the sweet phreattic nappe and the agricultural
- products
- the pollution of air soil and water due to the specific activity and to the technological and accidental lasses which if we consider of only 0.5-1% of the goods volumes, we may obtained daily waste of 100-150 t wich pollutes the ship enclosure with mettal ions carbon dust or solid and liquid chimic pruducts.To all these there are some additional defficiency that may appear in time to the waste water collecting pipes.

3.SOLUTIONS FOR THE REDUCTION OF THE ECOLOGIC IMPACT OF THE HARBOUR ARRANGEMENT

The solutions proposed for the reduction or compensation of the defavorable course concerning the environment must concerning the specific harbuor activity.

In the case of the Romanian harbours and especially of the case of the Constantza harbour (fig.2) , we present some solutions in order to limit the negative effect of these arrangements over the environment.

That is about the work conceiving and about the harbour enceinte exploiting.

There have been provided measures in orde to limit the polluting effects for each sector of activity, by using closed systems transports, by watering the waste dump of ore and carbon, by using the installations which retain the dust from cereals,cement or chemic products.

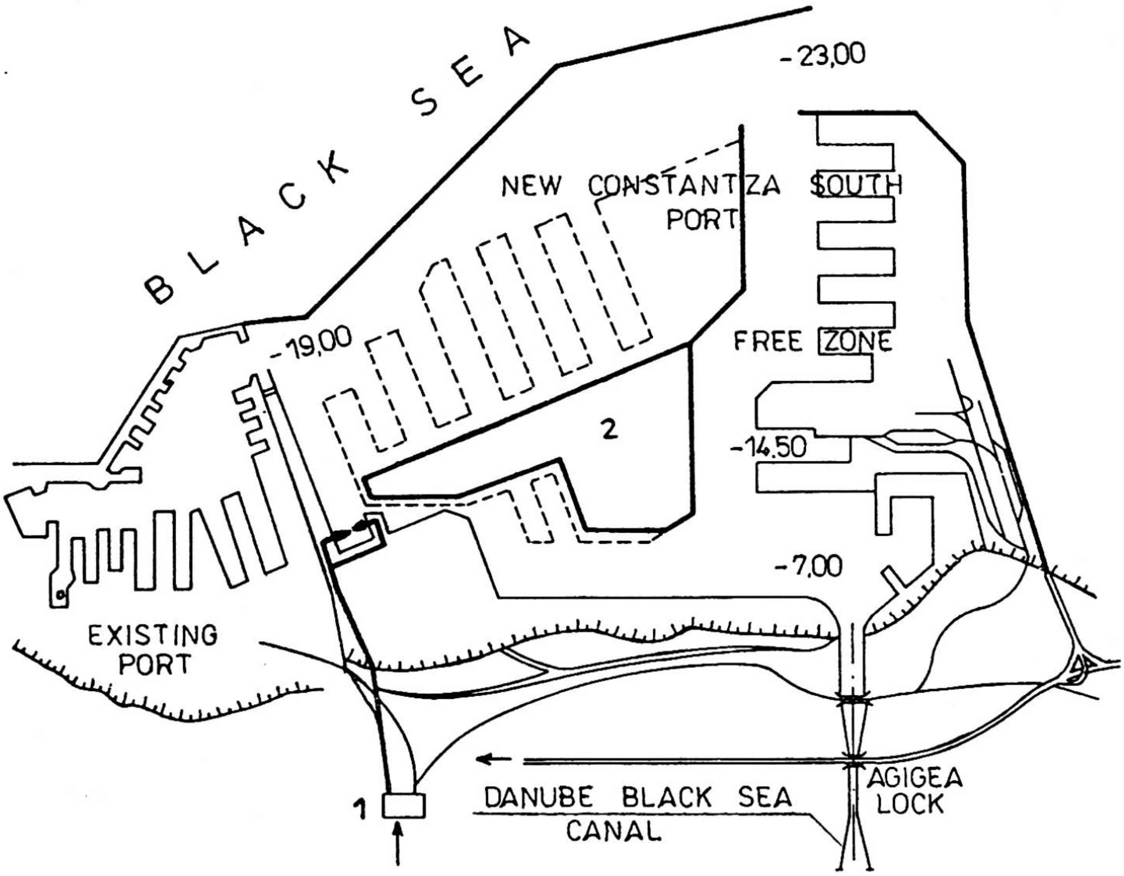
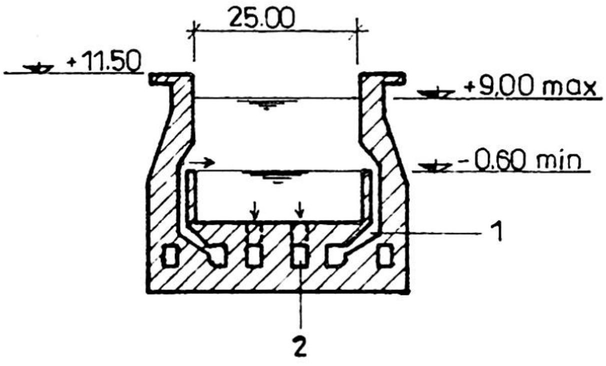


Fig.2 Constantza port
1-water treatment station; 2-enclosure for garbage and industrial wastes

We also have to elliminate the waste waters in the harbour bassin where the evacuation water pipes are too long, outside the harbour, until 15-20 m for a greater efficiency.
In order to collect, neutralize and to make valid the wastes it is necesary to endout the harbour on the land with special equipments. As solid wastes of Constantza and Constantza South harbours are very grea and it is difficult for the tewns to deposit these wastes, there have been built enclosures for them, together with earth-wich will constitute port territories, in connection with the further development of the port.

As for the conection of the salted water bassin of the port to the Danube-Black Sea Canal, there have been provided solutions for the elimination of the salted water along the Canal.So, for Agigea lock there has been privided a system filling-emptying through which the salted water with a greater density is allways kept at the lower part of the lock under the volume of the Canal (fig.3)
A special attention is given to the self-purification capacity of the sea, that is to decompose the polluting substances and to regime the natural characteristics of the clean water this process is mast active when the quantity of oxygen is greater.



Fiq.3-Lock of Danube-Black Sea Canal
1-gallery of sweet water; 2-gallery of salty water

That is why achieving bioactive works has an important role for the biological productivity and for raising the role of biochemistry and water oxygening.
In these sense there have made breackwaters for shore protection with bioactive role of type of artificial recif, which should made a divers power of biofiltre.
These diques located at about 400 m from the shore at -5.00 m fathom line, are of 200-300 m long and made of hole blocks protected with stabilopods (fig.4)

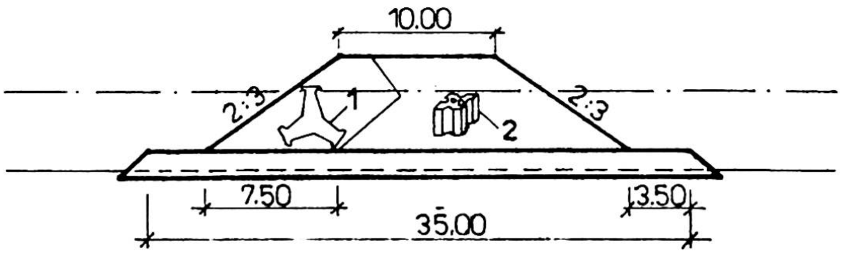


Fig.4 Breakwater-cross section
1-stabilopod 200 KN; 2-bioactiv block 150 KN

In order to increase such on artificial recif, there have been provided bioactiv blocks, wich should provide, favorable condition to the sea life.That may be done by practicing into the block bodies holes of 200-250 mm diametre wich should allow the water circulation (fig.5).

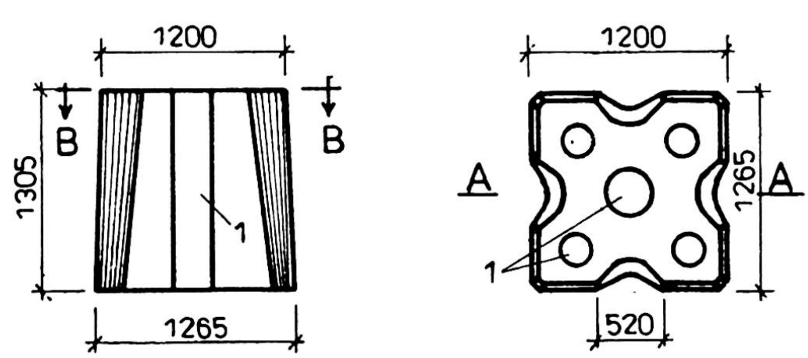


Fig.5 Concrete block (G=150 KN) acted biollogically
1-cylindric emptys

To a block of 15 t we may obtain a grawth of about 8 sq.m. that is 40%. The increasing of efficiency of these artificial recifs is obtained without suplementary investments.

* *
*

The achievements of the above objectives implie important material and financiar resources but must take into account the ecologie keeping and the environment protection, ecology becoming the first step.

Impact of Transmission Line Towers on Environment

Impact des pylônes à haute tension sur l'environnement

Umweltbeeinträchtingung durch Hochspannungsmaste

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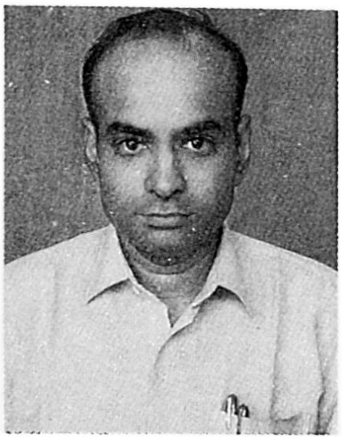


Santhakumar received his B.E., Civil, and M.Sc. (Struc.) from College of Eng. Guindy. He was Commonwealth Scholar at University of Canterbury, Christchurch, New Zealand where he obtained his Ph.D. For 25 years has been teaching and guiding research at Anna University. He has authored a book on Transmission Line Towers.

SUMMARY
The paper investigates the land use and environmental issues which are becoming guiding criteria for the development of transmission lines and towers. The possibility of multicircuiting and higher transmission voltages for minimising ground space and overall dimensional requirements are discussed. Development of new shapes, forms, and issues which are important for safety have also been included.

RÉSUMÉ
L'article examine les coutumes du pays et les sujets relatifs à l'environnement en tant que critères directeurs pour le développement des lignes à haute tension et de leurs pylônes. Il envisage les possibilités de regrouper ensemble plusieurs lignes et d'augmenter les tensions transportées, en vue de réduire les tracés et leurs dimensions hors tout, de mettre au point de nouvelles formes et sections de pylônes. Les aspects de la sécurité sont également traités.

ZUSAMMENFASSUNG
Der Aufsatz untersucht den Landverbrauch und Umweltgesichtspunkte als Leitkriterien bei der Entwicklung von Hochspannungsfreileitungen und deren Masten. Es geht um Möglichkeiten der Zusammenlegung von Leitungen und Erhöhung der Übertragungsspannung zwecks Reduktion der Abmessungen, um neue Mastformen und Sicherheitsaspekte.

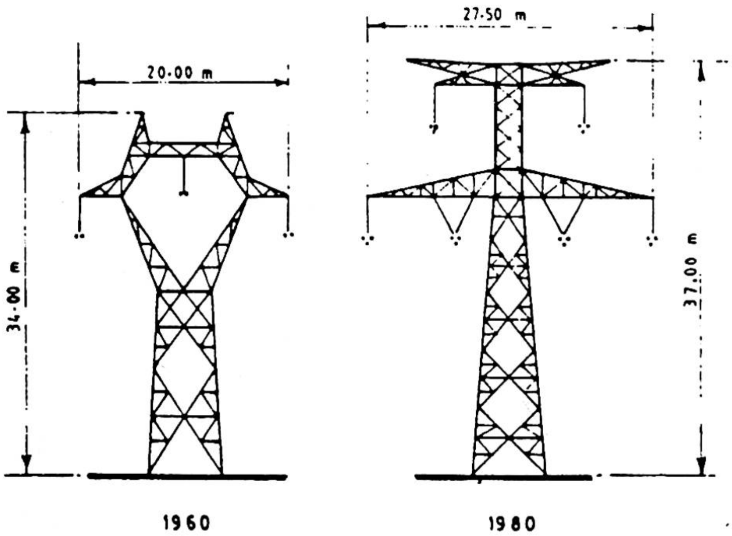
1. INTRODUCTION

In transmission line networks associated with power projects, the land use consideration becomes vital because of escalating land cost. In addition there is the question of impact on environment - this falls into two categories - (i) aesthetics and (ii) safty (effect on health).

2. RIGHT OF WAY

Way leaves are becoming costly and sometimes difficult to obtain. Both in densly populated countries and in industrial nations the shortage of land and enviornmental resources are being keenly felt.

Studies made in France [1,2] show that for the first 400 KV single circuit line using a 2 x 411 sq. mm conductor (year 1960), the transmisssion capacity was 1000 MW, that for double-circuit line using 3 x 570 sq.mm conductor constructed since 1980, the transmission capacity is 4000 MW for obout the same distance covered. Considering the tower confugaration employed for the two cases, it is seen that the transmission capacity has increased from 1.5 MW per Sq.metres covered area to 4 MW per Sq.meters. This is a distict better use of scarcely available space (land use) as shown in Fig. 1.



1 circuit 2 x 411mm² — 1000MW — 1.5MW/m²

2 circuits 3 x 570mm² — 4000MW — 4MW/m²

Fig.1 Power carrying capacity of lines

Fig. 2 compares the right of way for a 1100 KV and 500KV transmission. The advantage of UHV transmission with respect to land use is more than three fold. Fig. 3 compares land use for 800 KV with that required for 400 KV for the approximately same transmission capacity.

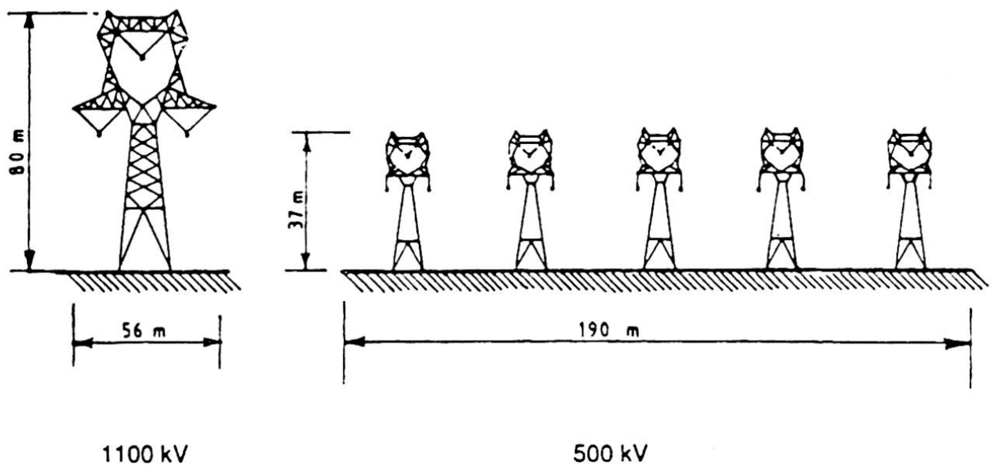


Fig.2 Right of way comparision between 1100 KV and 500 KV

For carrying power at UHV very low profile lines have been conceived. These designs have high degree of flexibility so that lines can accomodate characterstics of land (Fig. 4).

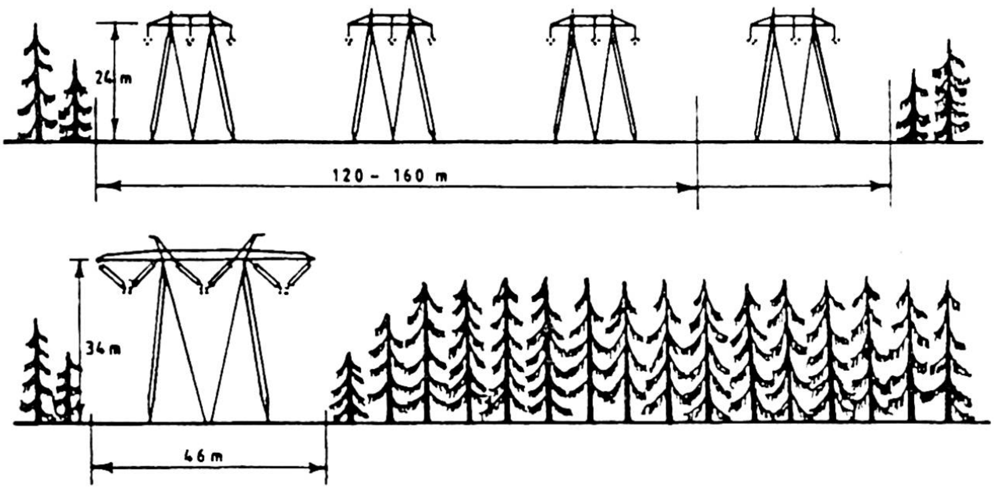


Fig.3 Destruction of forests caused by lower voltage transmission

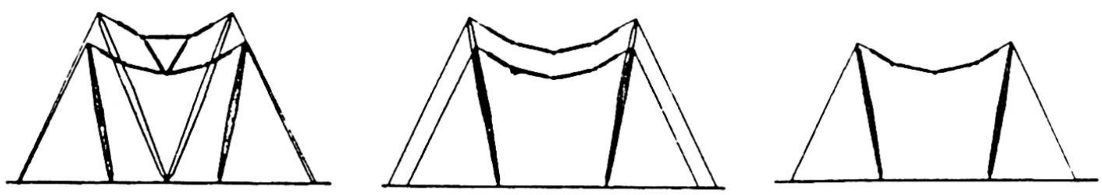


Fig.4 Non-conventional UHV Line

An unconventional 1065 KV tower has dimensions comparable with that of existing 765 KV lines and also fits better with the environment.(Fig. 5)

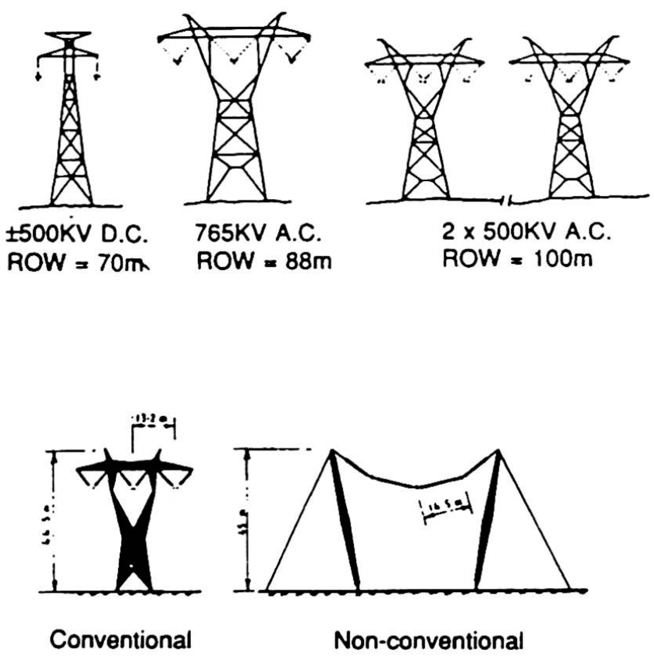


Fig.5 Better aesthetics of non-conventional tower

3. AESTHETICS

Ground occupancy and overhead clearence are basic considerations for right of way whereas the appearance and how the tower merges with the surrounding landscape to achieve an overall harmony becomes important for aesthetic aspect..

Aesthetic considerations have forced the development of towers designed specifically for appearance over and above thier structure and functional purposes.

Novel computer applications have been advocated for route planning. A digital terrain modelis used from which computer produced visibility contours can be mapped. Subsequently this can be used for tailoring the shape of the tower.

The above method enables to select the direction of a line in a particular terrrain under consideration and fix up the line route in such a manner that architectural features, picturesque scenes and touristic interests are retained and that environment as a whole is subjected to least possible damage. Electricity de France has now established a "Silene" workshop at which models of landscapes where transmission lines is to be located is developed.

4. SAFETY

The principal factors of environmental interference related to UHV lines are

* Corona effect - audible noice,radio interferece, generations of ozone and nitrous oxide.
* Effect of fields - Interference due to electronic and magnetic fields on human lives.

The importance of the above are briefly discussed [5,6] below.

4.1 Biological effects

Occasional exposure to the electric field generated by transmission lines do not present a hazard to human life. It is possible (but not established) continous long term repeated exposure to electric field exceeding 2.5 kV/m might be harmful. Allowing for a safty factor an interim 1.6 kV/m edge of right of way should be recommended.

4.2 Audible noice

Potential effects of noise on human ears include temporary or permanant of ear's functioning, nevous tension, fatigue, sleep interference and attendant annoyance. The number of time the sound level goes beyond 52 db(A) should be kept low.

4.3 Electric shock

Grounding of fixed metal objects on right of way will ensure minimization of risk against electric shock.

4.4 Effect on pacemaker

The fields produced may interfere with cardiac pacemaker. It is important to check the operation of cardiac pacemake to verify this.

5. CONCLUSION

The land use and environmental considerations will become more and more the guiding criteria for develoment of transmission lines. Therefore the long-term perspective of system network should be evolved and improved from time to time. This will enable multicircuiting and higher transmission voltages to be adopted consistant with system reliability. The object of reducing the ground space and overall dimensions of structure can thus be achieved. In the end aesthetic and safty aspects of these lines which are not considered thus for are likely to become deciding issues in future.

REFERENCES

1. MURTY S.S. and SANTHAKUMAR A.R., Transmission line Towers - Mċ Graw Hill Book Co., Sigapure, 1990.

2. CHARLES AVRIL and FERNAND QUEY, Evolution de la' construction des lignes a haute tension, Revue Generarale de l'Electricite - Numero Special, September 1971.

3. OLOV EDBERG (ed), Extra High voltage Transmission in Sweden,Vettenfall,Swedish State Power Board, 1985.

4. WORLD HEALTH ORGANISATION, Extremely Low Frequency (ELF) Fields, Environmental Health Criteria 35, Geneva, 1984.

5. CIGRE SC22-WG02, The Environmental Impacts of High Voltage Overhead Transmission Lines,September 1986.

6. STATE OF NEW YORK PUBLIC SERVICE COMMISION, Order containing Interim Transmission Line Electric Field Standard, April 1988.

On Bridge-Environment Relations in Japanese Cities

Relations entre pont et environnement dans des villes japonaises

Verhältnis von Brücke und Umwelt in japanischen Städten

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SUMMARY
Specific natural scenery, diverse terrain conditions, and an intensive expansion of communication requirements, colliding with major lack of space, mean that Japanese cities already contain numerous bridge constructions, showing an accelerated demand for many more in future. Those aspects, together with a definite impact of cultural heritage, display some characteristic features of bridge-environment relations, discussed in this paper.

RÉSUMÉ
Le milieu naturel spécifique, les conditions variées et la croissance intensive des nécessités du trafic, face à l'insuffisance de l'espace, font que les villes japonaises sont bien pourvues en ponts. A l'avenir, elles auront encore besoin de nombreux ponts nouveaux. Ces problèmes, liés de plus à l'influence de l'héritage culturel, donnent un caractère particulier aux relations entre le pont et l' environnement, analysé dans l'article.

ZUSAMMENFASSUNG
Eigenartige Naturszenerie, mannigfaltige Geländebedingungen und eine intensive Expansion der Verkehrserforderungen trott großem Raummangel bewirken, daß japanische Metropolen, bereits durch zahlreiche Brückenkonstruktionen geprägt, künftig noch viele mehr nötig haben werden. Diese Faktoren, von kultureller Tradition stark beeinflußt, ergeben gewisse besondere Eigenschaften in der Beziehung von Brücke und Umwelt, wie in diesem Beitrag erörtert.

1. INTRODUCTION

A bridge represents one of the most spontaneous constructions accompanying the human genus from its very beginning. Conformity with nature of the primitive bridge beam, arch, and suspension systems, together with the inborn character of their structural substance, formed a perfect bridge-environment unity and, therefore, satisfied automatically all presently accepted requirements of environmental consistency. Within ages, because of the unconcerned activity of men, bridge constructions became less innate, more and more formally unjust, thus injuring the natural harmony of the "genius loci". Nevertheless, gradually a return to allover structural simplicity, resulting in a more consonant bridge project, was felt necessary. But it was only the first half of this century that problems of bridge aesthetics and environmental fitness became important factors of bridge design. Competent research in that area resulted later in mature references, like /1/ or /2/; relevant, practice oriented Japanese particulars have been discussed in /3/, /4/, /5/, /6/, and /7/. This report concentrates on those matters confined to the conditions presently typical for large Japanese metropolies - by the examination of few characteristic case features.

2. BACKGROUND

Bridge constructions in Japan developed rapidly after World War II, parallel to the country's outstanding achievements in the technical civilization, as a whole. An accelerated demand for easy communication resulted in a considerable expansion of the rail- and highway network, connecting presently - by land-links (bridges or tunnels) - all the four main islands of Japan: Kyushu, Honshu, Shikoku, and Hokkaido. Simultaneously, a vigorous growth of the country's metropolitan regions has been observed, creating the situation that already big cities became much bigger - forming urban organisms of multi-million inhabitants, thus introducing new problems concerning the cities' "domestic" traffic. Present formulation of up-to-date strategies for future technology development of Japanese cities, Technopolis Program /8/, can make those problems only more acute.

3. GENERAL STATEMENTS

The most inherent attribute of Japanese cities having, presently, an essential impact on any sort of urban infrastructure, is major lack of space. Fig. 1 is a good illustration of that state, showing the characteristic cityscape of old Tokyo: congestion of differently shaped buildings and communication facilities at the place of the multilevelled intersection of Kanda-River, Marunouchi Subway Line, JR Chuo and Sobu Lines, and of a road bridge (the picture was made from), near Ochanomizu Station. Rapid and unrestrained formation of that urban space and no much understanding for aesthetical arguments at the time of construction created an inhospitable area, with little relation to the original environment, to-day difficult to be improved.

A new feature, having presently much influence on the appearance of Japanese metropolies, mostly maritime, is their gradual stepping into the nearby sea area by building artificial islands and suitable bridge routes; most of them have been constructed in Tokyo and Osaka bays. A representative cityscape is given in Fig. 2, showing a part of the Osaka Harbour with the Minato Viaduct No.1 (foreground), the cable stayed Aji-Gawa Bridge, and the mono-cable Hokko Bridge of the Hanshin Expressway Public Corporation, farther back. The chosen bridge types positively dominate over the traditional port environment. Elevated expressway proves to be an integral part of urban life; shown spiral access ramp uses well the limited space, conforming the feeling of economy.

Tracing of urban expressways may be very difficult. A modern arrangement is demonstrated in Fig. 3 where curving between towering buildings of down-town Osaka, and aligning to the existing rivers, was found necessary.

4. SOME PARTICULARS

Present-day bridges in Japan, urban in particular, are considered public spaces to be shaped with special care. Therefore, in bridge design a close co-operation of experts in structural mechanics, bridge engineering, architecture, and environmental design is being pracitced /9/.

An example of a modern urban expressway, conform with local tradition of the spot, is shown in Fig. 4. It is the Semba Rooftop Expressway of the Higashi-Osaka Route which, in order to maintain the textile wholesale function of this district, was constructed in the rooftop fashion, accomodating many shops underneath.

It was already mentioned that in Japan many elevated urban expressways are located over, or are bordering, the pretty frequent water-courses, as the only public spaces still available for construction. Fig. 5 illustrates certain part of the Nakamura-River in Yokohama, between China Town and Motomachi Shopping Center. Because of the popularity of that place, many footbridges have been thrown across the river, under the expressway construction, to organize the pedestrian traffic. Most of those bridges have been specially designed, to comfort the demands of bridge aesthetics and environmental fitness; this concerned the form and the colour of total structures and of all their details.

Some particular learning on urban bridge-environment relations in Japan results from Figs. 6 and 7. Extensive construction of elevated urban roads has developed some new space below them. Depending upon the local situation, this space is used in a variety of ways. Priority is given to facilities benefitting the public, such as: plazas, parks and parking lots, whereby all those places are designed with much attention for their aesthetical expression and environmental consistency. Thus, Fig. 6 pictures an environmentally sound leisure place at the Shirokita Channel fishing pond under the Osaka-Moriguchi Route, and Fig. 7 - attractive mural painting on expressway piers, in order to brighten up the monotony of the accomodated parking area.

New Japanese trends in the development of urban transportation systems result from Fig. 8. It is suggested to integrate various means of communication in one construction including, from top to bottom: expressway, railway, pedestrian zone with shops, recreation areas, parking lots, etc., and subway. For environmental reasons, at the usual street level green areas, together with planted trees and shrubs, are anticipated.

There are already some elements of such transportation systems completed. Fig. 9 shows the structure of the Hanshin Expressway Wangan Route incorporated with the trunk line of the New Osaka Transportation System, penetrating the reclaimed land of the Osaka South Port; it is visible that aesthetics was here an essential factor of design.

Footbridges are becoming very important elements of Japanese cityscape. The necessity to arrange the urban communication facilities in a threedimensional manner, specially - to improve the pedestrian communication within the areas of intense accumulation of people, causes that footway bridges, promenades and plaza platforms are often applied to meet those needs. Fig. 10 demonstrates the modern Osaka Castle Promenade, crossing smoothly a rather dense urban area on the way to old Osaka Castle - an attractive place in respect of tourism. The fully screened construction protects the numerous passers-by against any bad weather influence, but leaving an unrestrained view on the surroundings by skillfully glassed walls and roofing; suitable detailing and colouring produces an aesthetically affirmative impression of this construction.

Another modern pedestrian bridge, shaped according to the traditional design of Japan, is one built in Nagoya and given in Fig. 11. Many present bridges follow that idea but numerous are also less traditional, adjusting to the conventional character of the adjacent urban area. Because of the usually small

Fig. 1 Urban space in old fashion: Tokyo - Ochanomizu

Fig. 2 Impact of harbour on urban space: Osaka

Fig. 3 Modern urban space: Osaka - Ikeda Route

Fig. 4 Semba Rooftop Expressway: Osaka

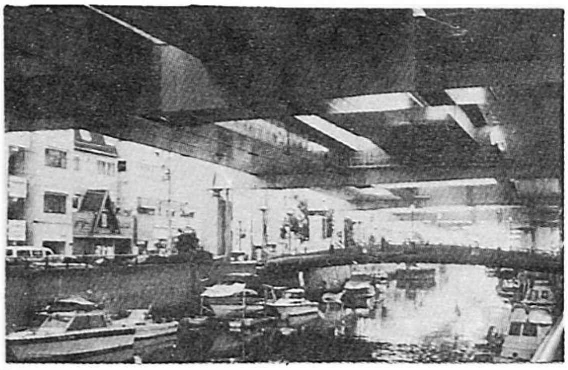

Fig. 5 Expressway/water-course

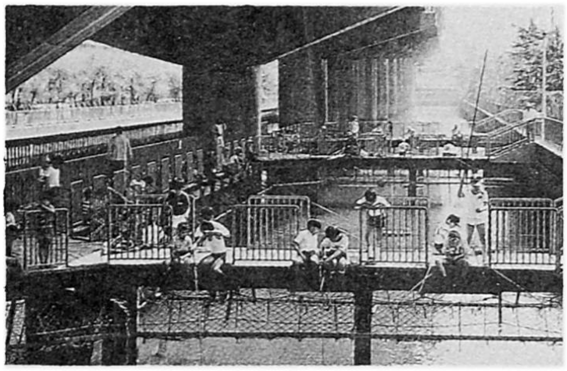

Fig. 6 Co-existence of structure and environment: Osaka - Moriguchi Route

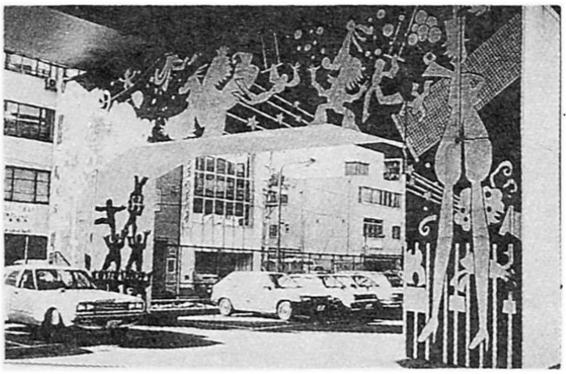

Fig. 7 Coherence of Structure and art: Osaka

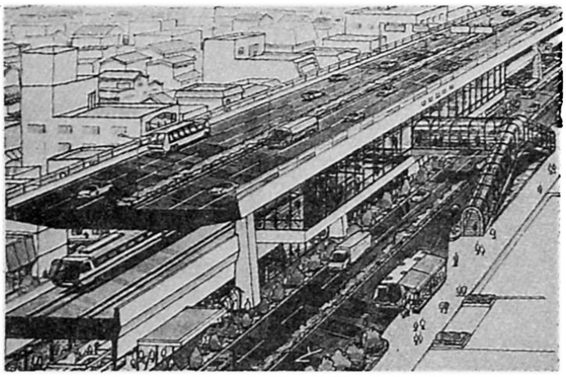

Fig. 8 Idea on integrated urban communication

Fig. 9 Modern expressway/trunk combination: Osaka - Wangan Route

Fig.10 Modern footway promenade: Osaka

Fig.11 Modern footway bridge: Nagoya - Shirakawa

scale of those structures, environmentally fair detailing is here more important than elsewhere, becoming a prominent design factor.

The effect of bridge accessories on the esthetical perception of bridges, urban in particular, became major point of interest in Japan; corresponding manual is expressed by /10/. It was found that such accesories as railing, newel post, illumination post, walkway pavement, drainage pipe, and noise barrier, may exert a large impact on the overall bridge impression. Concerning the railing, its shape, quality of materials, and colour, are influential factors of design. The purpose of the newel post is to accentuate the bridge versus the normal road; its form and materials depend mainly upon regional characteristics and historical backgrounds. Walking space is essentially governed by the pavement that must promote the feelings of comfort and safety of the pedestrians, having a proper moving line and rhythm, and being well balanced with bridge railings and illumination posts. Drainage pipes may spoil the bridge view and, therefore, it is desirable to place them inconspicuously. Noise barriers, necessary to comfort the nearby inhabitants, should be well incorporated into the local environment and the aesthetical image of bridge.

5. CONCLUSIONS

Present bridge design in Japan, urban in particular, is effectively controlled by the demands of aesthetics and environmental consistency. Bridges are public spaces treated with extra care. Therefore, much attention is paid to make them attractive objects determining the cityscape. Appropriate co-operation of bridge engineers and environmental designers is very much successful. Accumulated experience caused that professional aesthetic design manuals could be developed. Symbiosis of old national culture and high standards of bridge science and technology is a characteristic feature of Japanese achievements in that field.

REFERENCES

1. WASIUTYŃSKI Z., On the Architecture of Bridges (in Polish). PWN, Warsaw 1971.

2. LEONHARDT F., Brücken - Bridges, Ästhetik und Gestaltung - Aesthetics and Design. Deutsche Verlags-Anstalt, 2. Aufl., Stuttgart 1984.

3. TAHARA Ya. and NAKAMURA Yo., On the Manual for Aesthetic Design of Bridges. IABSE 11th Congress Vienna 1980, Final Report, 101-108, Zurich 1980.

4. ITO M., TAMURA Yu. and YAMASE T., Methodology of Colour Selection for Steel Girder Bridges. IABSE 11th Congress Vienna 1980, Final Report, 109-114, Zurich 1980.

5. OHTA T., TAKAHASHI N. and YAMANE T., Aesthetic Design Method for Bridges. Journal of Structural Engineering, 113(1987), 8, 1678-1687.

6. CYWIŃSKI Z. and CZERNICHOWSKA E., Some Aspects of Bridge Serviceability in Japan. Conference "Durability and Service Life of Bridge Structures", Proceedings, 79-86, Poznań 1989.

7. CYWIŃSKI Z. and CZERNICHOWSKA E., On the Environmental Consistency of Bridges. IABSE Symposium Leningrad 1991; paper preliminarily accepted.

8. EDDINGTON D.W., New Strategies for Technology Development in Japanese Cities and Regions. Town Planning Review 60(1989), 1, 1-27.

9. FUJIMOTO, K., Bridging a better path to effective space planning. Japan Times, 1990.10.10.

10. SUZUKI, T., On improvement of bridge accessories for aesthetic design. Japan Road Association Annual Report on Roads (1987), 10-22.

Contrôle de l'étanchéité des enceintes nucléaires à double paroi

Dichtigkeitskontrolle doppelwandiger KKW-Sicherheitsbehälter

Sealing Checks on Double-Walled Nuclear Vessels

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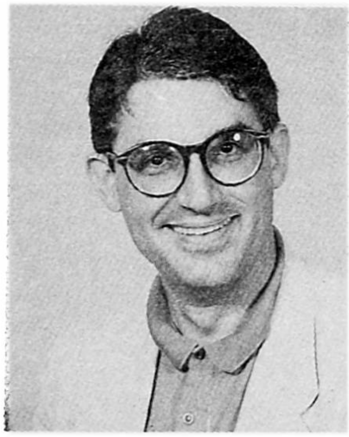

Gilbert Jancovici, né en 1954, est issu de la Promotion Supérieure du Travail d'EDF (POT 1980). Après s'être occupé de métrologie gazière, il a participé à l'ordonnancement des grands projets d'équipement nucléaire. Il dirige actuellement la réalisation des mesures d'étanchéité des enceintes nucléaires françaises.

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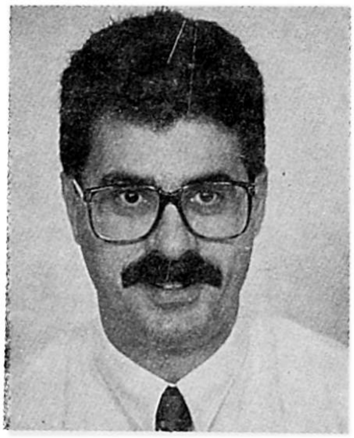


Patrick Merino né en 1954, obtint ses diplômes à Grenoble (DUT Mesures Physiques). Depuis 1980 il développe et met en œuvre les méthodes de mesure du taux de fuite des enceintes de confinnement.

RÉSUMÉ

Parmi les 58 tranches nucléaires qu'Electricité de France exploite et construit, 24 sont équipées d'enceintes à double paroi pour la protection de l'environnement, en cas de situation accidentelle. Les bâtiments réacteurs sont constitués de deux enceintes superposées. Cette disposition permet, en cas d'accident majeur (rupture du circuit primaire se traduisant par une montée en pression de l'espace confiné) de collecter et de filtrer les effluents par l'espace entre-enceinte mis en dépression.

ZUSAMMENFASSUNG

Von 58 Kernkraftwerken, die die "Electricité de France" gebaut hat und betreibt, sind 24 mit einem doppelten Einschluss für den Störfall versehen. Sollte ein Bruch im Primärkreislauf zum Druckanstieg im Ringspalt führen, so gestattet diese Konstruktion den Abzug und die Filterung der kontaminierten Luft durch Unterdruck. Der Beitrag beschreibt verschiedene getestete Methoden zur Messung der nicht gefassten Leckagen, die vor allem aus den Nebengebäuden während des Drucktest entweichen.

SUMMARY

Of 58 nuclear power plants built and operated by the "Electricité de France" 24 have been provided with a double-walled enclosure in the case of a fault. If a break in the primary circuit were to lead to a pressure rise in the ring-shaped gap, then this type of construction allows the contaminated air to be removed and filtered by means of underpressure. The paper describes different tested methods for measuring the leaks that could not be controlled, above all of air escaping from auxiliary buildings during the pressure test.

1. INTRODUCTION

La particularité des enceintes à double paroi réside dans le concept de sûreté lié au collectage des fuites en cas d'accident majeur. L'enceinte interne, en béton précontraint, est destinée à supporter la pression et à assurer l'étanchéité. L'enceinte externe, en béton armé, doit résister aux agressions extérieures telles que chute d'avion ou explosion. En fonctionnement normal, l'espace entre ces enceintes est maintenu en légère dépression (- 15 mbar) et toute fuite à travers la paroi intérieure doit être collectée et filtrée avant rejet. Le taux de fuite global de l'enceinte interne ne doit pas dépasser 1 % par jour de la masse totale de gaz contenu dans cette enceinte, à la pression correspondant à la perte du réfrigérant primaire. La fuite maximum tolérée correspond à environ 150 N m^3/h à 5 bar absolus. On sait mesurer cette fuite avec précision (voir l'article de C. DUBS au congrès de l'AFPC à Helsinki en 1988). Pour les enceintes à double paroi, le problème consiste à évaluer de façon suffisament précise, dans ces conditions, la part de la fuite non collectée par l'espace entre-enceinte. Cette fuite s'échappe en grande partie dans les bâtiments périphériques, et pour une faible part dans l'environnement, par les traversées mécaniques ou par le radier.

Trois méthodes de mesure ont été expérimentées par EDF.

2. ANALYSE DU PROBLEME

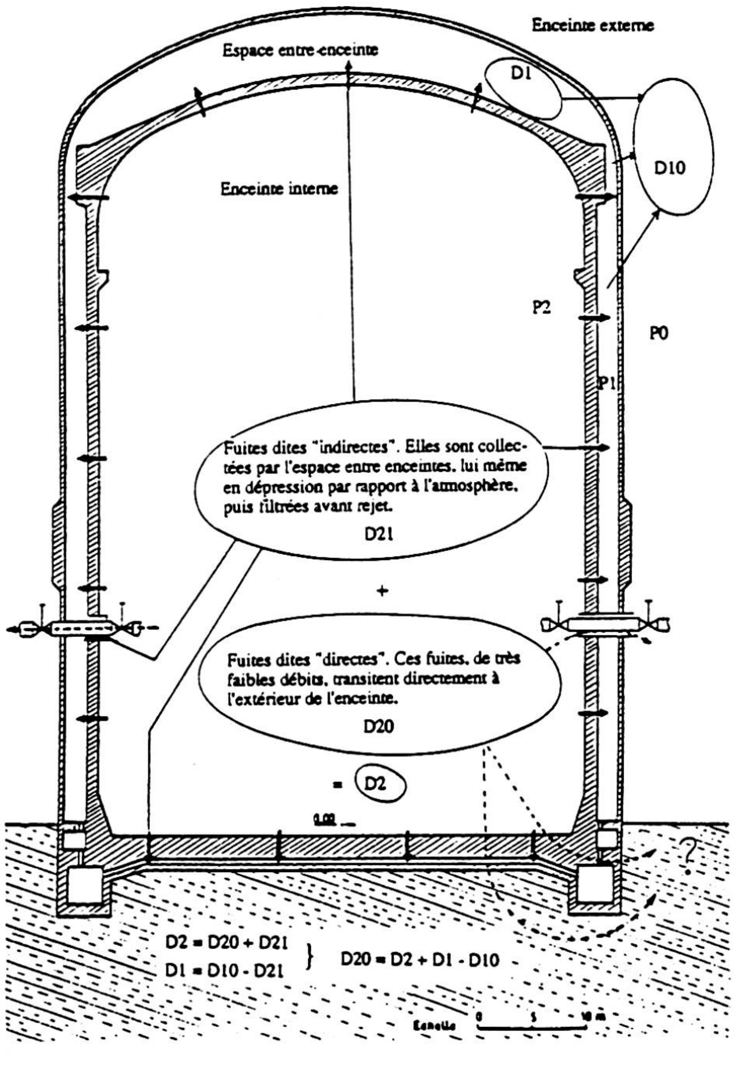


Figure 1 : Bilan des fuites

En considérant une mise en pression de l'enceinte interne correspondant à l'accident de perte du réfrigérant primaire, le bilan des fuites sans dépressurisation de l'espace entre-enceinte est représenté figure 1.

On distingue tout d'abord les fuites dites "indirectes" D21 qui sont collectées par l'espace entre-enceinte. On identifie ensuite les fuites dites "directes" D20 qui s'échappent du bâtiment réacteur par les traversées mécaniques ou par le radier. L'ensemble de ces fuites représente la fuite globale D2 de l'enceinte interne. L'espace entre-enceinte laisse échapper vers l'extérieur une fuite D10 à travers l'enceinte externe.

Le bilan global de cette configuration peut-être représenté sous la forme :

$$\left.\begin{aligned} D2 &= D20 + D21 \\ D1 &= D10 - D21 \end{aligned}\right\} \Rightarrow D20 = D2 + D1 - D10$$

(Ce qui sort d'une cavité est négatif, ce qui entre est positif).

D2 est mesuré par la méthode classique de détermination du taux de fuite global des enceintes nucléaires.

Il reste donc à évaluer les débits D1 et D10, sachant qu'il n'est pas possible de mesurer directement la fuite D20.

3. DETERMINATION D'UNE METHODE DE MESURE DES FUITES "DIRECTES"

Les méthodes expérimentées prennent en compte la mise en pression de l'enceinte interne à la pression d'accident, soit environ 5 bar absolus. Cette condition est réalisée aux épreuves périodiques d'essais d'enceintes. Par ailleurs, elles mettent en oeuvre la mesure du taux de fuite global de l'enceinte interne D2, le débit de fuites "directes" étant obtenu par différence.

3.1 Méthode du débitmètre à faible perte de charge

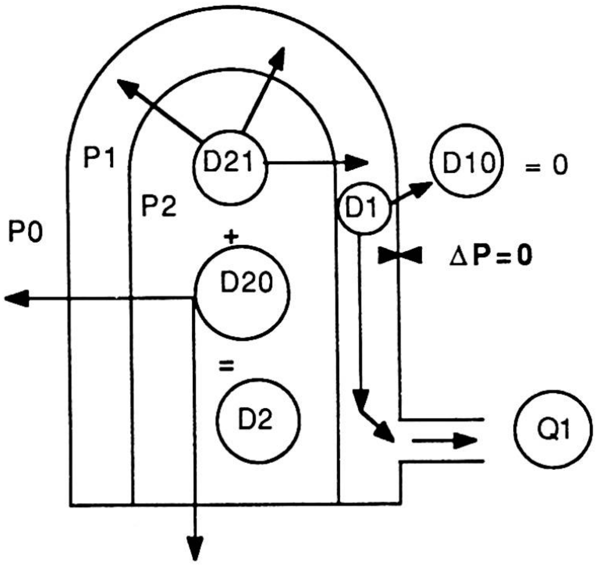


Figure 2 : Méthode du débitmètre

Le principe de cette méthode est de collecter l'ensemble de la fuite D1 à travers un débitmètre à faible perte de charge, et de maintenir pendant la mesure, l'équipression entre la pression de l'espace entre-enceinte et la pression atmosphérique. Ceci revient à annuler le débit D10 (cf. figure 2). Le bilan de la méthode peut donc s'écrire :

$$\begin{cases} \Delta P = P1 - P0 = 0 \Rightarrow D10 = 0 \\ Q1 = -D1 \end{cases}$$

On en tire : $D20 = D2 - Q1$

Le problème de cette méthode consiste à obtenir un écart de pression voisin de zéro, ce qui nécessite de disposer d'un débitmètre ayant les caractéristiques suivantes : plage de 150 N m^3/h à 250 N m^3/h avec une précision inférieure à 1 % et une perte de charge inférieure à 0,2 mbar à débit maximum. L'incertitude de ce type de mesure avoisine les ± 10 N m^3/h dans les conditions optimales.

3.2 Méthode du traceur hélium

La pressurisation de l'enceinte interne est réalisée avec un mélange air/hélium à 0,1 % d'hélium. On dépressurise l'espace entre-enceinte selon les conditions normales de fonctionnement.

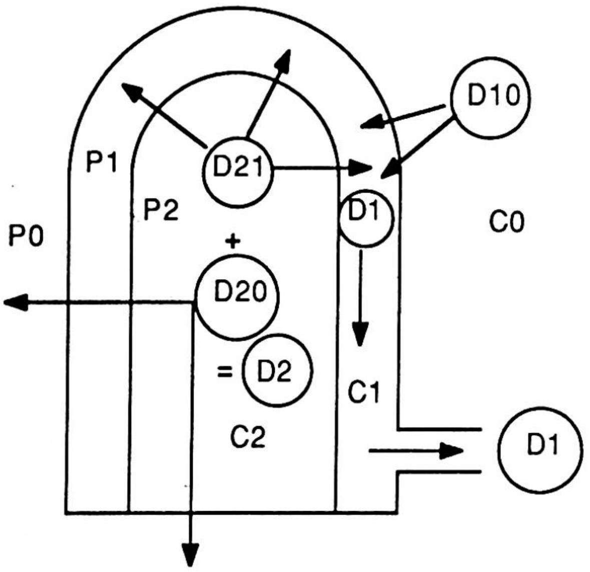


Figure 3 : Méthode du traceur hélium

On a donc un apport d'air extérieur D10. Le bilan des échanges gazeux peut s'écrire :

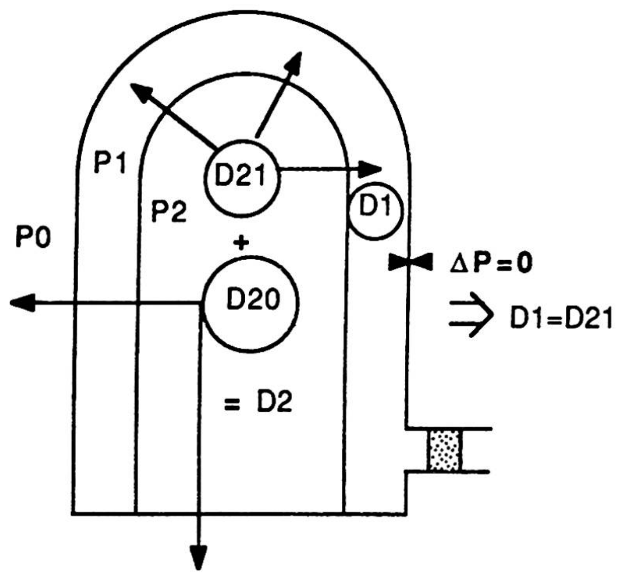
$$\left.\begin{array}{l} D2 = D21 + D20 \\ D1 = D21 + D10 \end{array}\right\} \Rightarrow D20 = D2 - D1 + D10$$

En considérant les concentrations en hélium de l'atmosphère C0 et celles de l'espace confiné à l'intérieur de l'enceinte interne C1, on obtient :

$$D20 = D2 + D1 \frac{(C1 - C0)}{C0 - C2}$$

l'avantage de cette méthode est de ne pas nécessiter la prise en compte du débit D10. Par contre, de réelles difficultés sont rencontrées au niveau de la détermination de l'évolution des concentrations en hélium qui se font à l'aide d'un spectomètre de masse. L'incertitude sur ce type de mesure avoisine également les ± 10 N m^3/h avec un temps de réponse incompatible avec les contraintes de l'exploitation.

3.3 Méthode du taux de fuite "dynamique"



L'enceinte interne étant préssurisée à la pression nominale d'essai, on dépressurise l'espace entre-enceinte à environ - 10 mbar, puis on isole l'ensemble. Lorsque l'équipression entre P0 et P1 est réalisée, l'échange gazeux avec l'extérieur ne se fait plus que par les fuites "directes". Si on mesure simultanément les débits de fuites globaux D2 et D1 à l'instant précis ou $\Delta P = 0$, on obtient le débit de fuites "directes" D20 par différence :

$D20 = D2 - D1$

Cette méthode de mesure a été préférée aux deux autres de part la mise en oeuvre des moyens associés, ainsi que par l'évolution possible du niveau d'incertitude évalué dans un premier temps à ± 10 N m^3/h. De plus, la mesure est peu perturbée par les conditions climatiques.

Figure 4 : Méthode du taux de fuite "dynamique"

4. MISE EN OEUVRE DE LA METHODE RETENUE

4.1 Réalisation de la mesure

La méthode validée est donc celle de la mesure du taux de fuite "dynamique". Comme pour les autres méthodes, la mesure du débit de fuite global D2 de l'enceinte interne est réalisée grâce à la méthode absolue. On met en place une installation de mesure qui comporte plus de cinquante capteurs de haute précision (deux manomètres, quarante quatre sondes de température, dix hygromètres). Pour effectuer régulièrement les relevés sur les capteurs et réaliser les calculs nécessaires, on fait appel à un calculateur, une centrale d'acquisition des mesures et un voltmètre numérique de précision. Les capteurs de température et les hygromètres sont répartis à l'intérieur de l'enceinte, tandis que les manomètres et les autres appareils sont regroupés dans un local de mesure spécifique, près de la salle de commandes de la centrale. Les liaisons entre les capteurs placés dans le bâtiment réacteur et les appareils extérieurs sont réalisées grâce à des traversées électriques étanches.

Pour la mesure du débit de fuite global de l'espace entre-enceinte D1, on utilise une instrumentation équivalente. Neanmoins, pour tenir compte des variations éventuellement plus rapides des paramètres, il a été choisi des capteurs de température ayant des temps de réponse plus faibles et un doublement des points de mesure de la pression. La mesure de la pression atmosphérique est réalisée en trois points situés à 120°, à mi-hauteur du fût de l'enceinte externe. Un système de chicanes mis en place sur les prises de pression améliore la représentativité de la mesure.

L'écart de pression entre la pression atmosphérique et la pression de l'espace entre-enceinte est obtenu avec une très bonne précision grâce à une comparaison, juste avant l'essai, des valeurs données par chaque capteur, et une prise en compte de leur écart éventuel. Une vérification de la valeur trouvée est réalisée après l'essai.

4.2 Causes d'erreurs et incertitudes

La cause principale d'erreur réside dans l'évaluation des débits de fuite lorsque $\Delta P = 0$. La mesure sera d'autant plus précise que les débits seront faibles et que P0 sera stable. Par ailleurs, on calcule la pente de la courbe de variation de masse d'air sec $\frac{\Delta M}{M}$ pour des espaces de temps parfaitement symétriques autour de $\Delta P = 0$. On s'efforce également de multiplier le nombre d'acquisitions autour de $\Delta P = 0$ afin d'affiner le résultat. Enfin, on étalonne l'ensemble du système de mesure par une injection d'air "étalon" avant essai. On détermine de cette manière un coefficient de correction à appliquer à la mesure finale. Le calcul de l'incertitude totale tient compte des deux incertitudes sur la mesure des débits de fuites globaux. On y intègre l'erreur sur le coefficient de correction lié à l'injection de gaz "étalon" et l'erreur de détermination du ΔP nul. Cette incertitude ne dépasse pas ± 10 N m^3/h dans le plus mauvais cas, elle peut être améliorée par une meilleure analyse des dépouillements de données et par des étalonnages complémentaires.

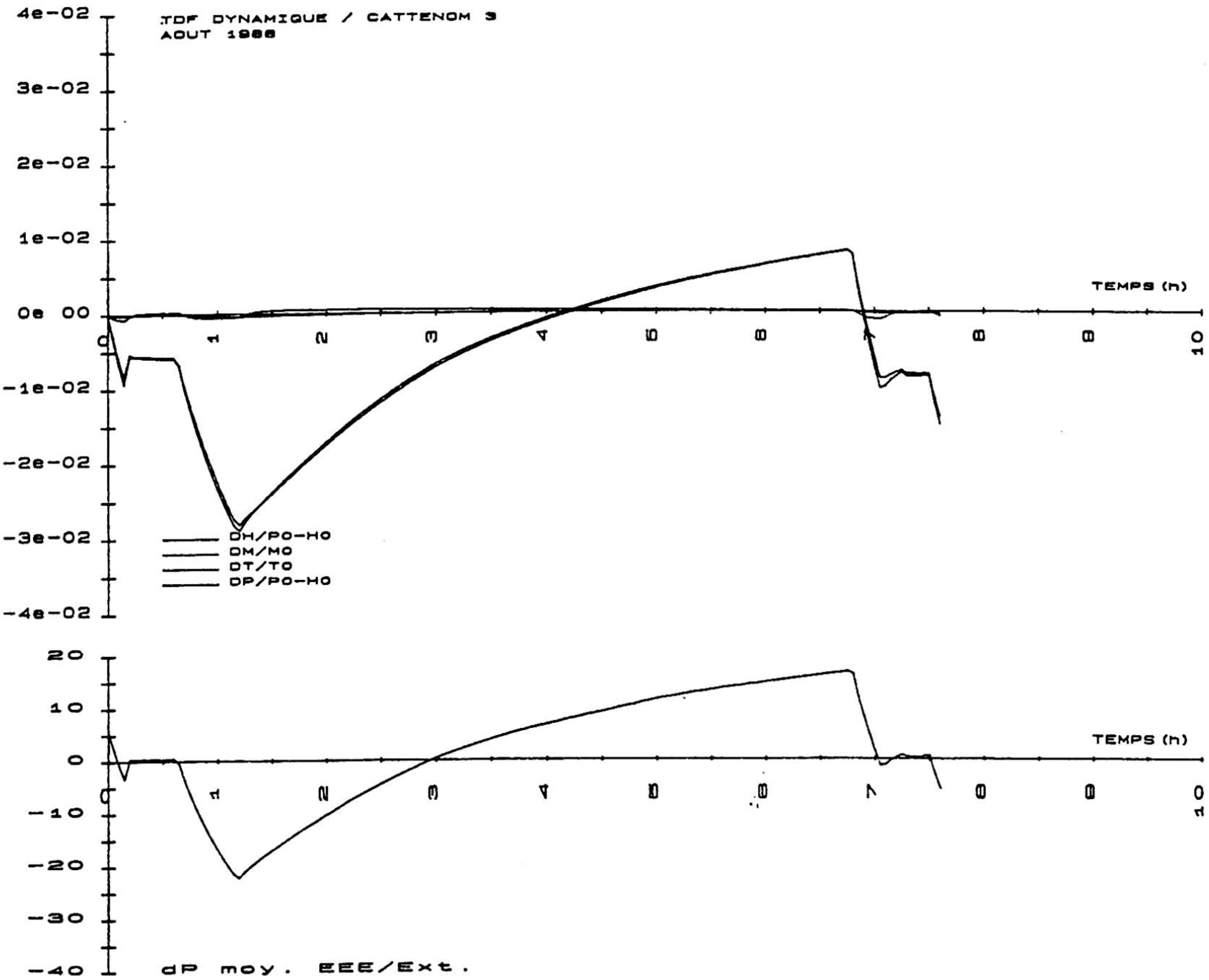


Figure 5 : Evolution de la variation de masse d'air sec dans l'espace entre-enceinte en fonction du temps et de la pression.

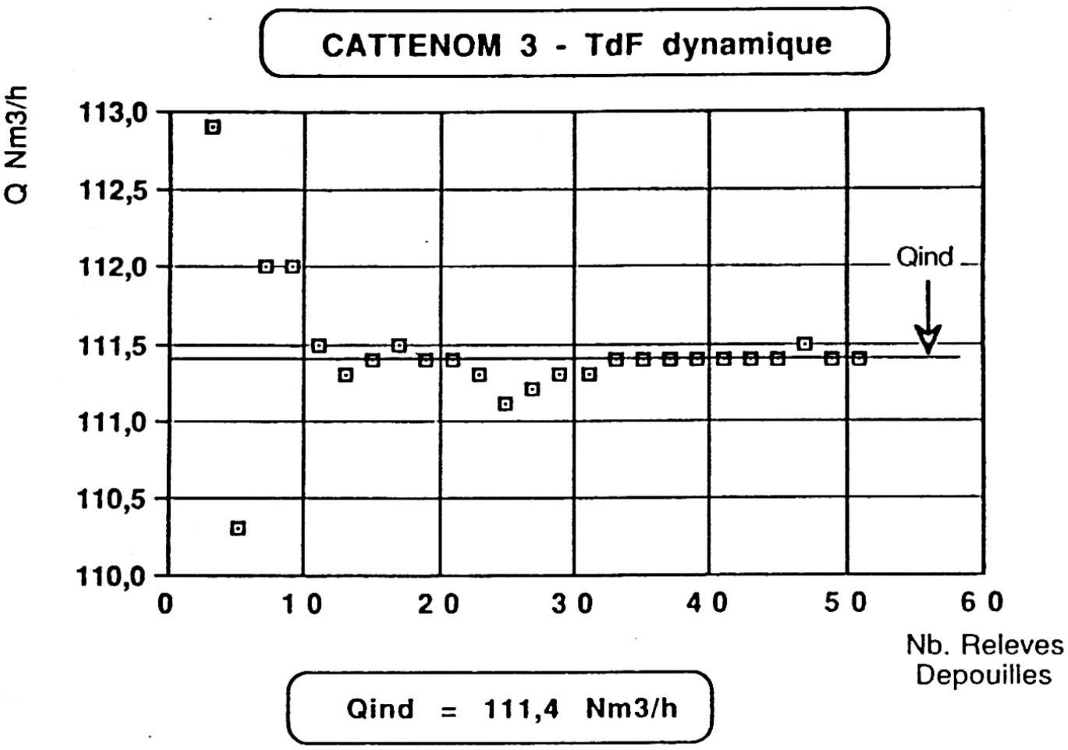


Figure 6 : Incidence du nombre de relevés dépouillés sur la détermination du débit de fuites "indirectes".

5. CONCLUSION

La méthode du taux de fuite "dynamique" retenue pour évaluer le débit des fuites "indirectes" des enceintes nucléaires à double paroi est une méthode fiable et évolutive. Elle met en oeuvre la méthode de mesure du taux de fuite global ou méthode dite "absolue", approuvée depuis près de dix ans pour le contrôle de l'étanchéité de l'ensemble des enceintes du parc nucléaire français. Des études en cours permettront d'apporter un meilleur résultat à la mesure. En effet, une détermination mathématique des équations des courbes d'évolution de la masse d'air sec ainsi que l'action entreprise pour minimiser l'ensemble des causes d'erreur permettront de réduire l'incertitude totale de façon significative. Par ailleurs, on a pu constater, d'après les relevés effectués, que les valeurs des débits de fuites"directes" étaient compatibles avec les débits de fuites globaux des enceintes à simple paroi avec peau d'étanchéité en acier. Les deux concepts d'enceintes donnent par conséquent toute garantie vis-à-vis des problèmes de sécurité nucléaire et de protection de l'environnement.

Concrete Structures for Risk Reduction on Industrial Plants

Ouvrages en béton pour réduction du risque des complexes industriels

Betonbauten zur Risikominderung in industriellen Anlagen

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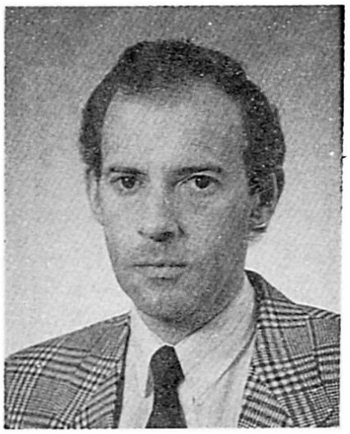

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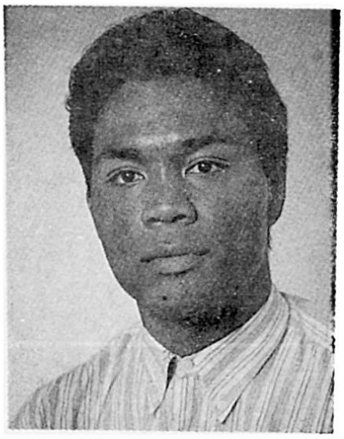

Melvin Asin, born 1966 received his masters degree at the Delft University of Technology in 1990. For one year involved in structural analysis of spherical structures under fire loading. At present employed at the university of Delft as researcher.

SUMMARY
Increasing number, scale and complexity of industrial facilities and the associated high risk potentials compel us to reconsider current safety concepts. A major point in this respect refers to the recognition that in case of Low Probability/High Consequence Risks risk reduction should be achieved primarily, may be exclusively, by reduction of the consequences. For reliable consequence reduction concrete protective structures with high built-in passive safety potentials offer most challenging prospects. The safety potentials of prestressed concrete pressure vessels for industrial use will be highlighted.

RÉSUMÉ
L'augmentation continue du nombre, de l'importance et de la complexité des installations industrielles et des risques potentiels en résultant, oblige à réviser les conceptions de sécurité actuelles. Il semble logique de penser que la maîtrise des conséquences doive entraîner en principe, voire à coup sûr, la réduction des risques dans le cas d'un rapport de faible probabilité à haut potentiel de risques. Par suite de leur sécurité passive inhérente, les constructions en béton précontraint sont fort bien appropriées pour réduire avec efficacité les dommages consécutifs. Ceci est illustré par un exemple de réservoirs sous pression réalisés en béton précontraint.

ZUSAMMENFASSUNG
Die immer grösser werdende Anzahl und Komplexität von industriellen Anlagen und die damit verknüpften Risiken zwingen zum Überdenken heutiger Sicherheitskonzepte. Gefährdungen geringer Eintretenswahrscheinlichkeit aber grossen Schadenpotentials sollten vornehmlich — wenn nicht ausschliesslich — durch die Beherrschung der Auswirkungen vermindert werden. Für Schadenbegrenzung sind Bauten aus vorgespanntem Beton, infolge ihrer vorragender passiven Sicherheit, sehr geeignet. Dies wird illustriert an Druckbehältern aus vorgespanntem Beton.

1. RISK CRITERIA AND RISK REDUCTION: SOME INTRODUCTORY REMARKS

For the evaluation of risk potentials in modern industrial facilities Quantitative Risk Analysis (QRA) has become increasingly popular. The QRA has turned out to be a most valuable tool for comparison of safety levels and for tracing the weak points in industrial processes and structures. Less emphasized, but of great importance in view of present and future safety considerations, is that QRA has taught us that past striking accidents must, in essence, be considered merely as precursor events and that more, and even more severe, accidents are bound to happen [1,2]. These penetrating lessons compel to reconsider current safety strategies and the role of QRA in them.
A major point of concern in this process of reconsideration refers to the eloquence of often adopted single-valued risk criteria. Among them the *fatality rate*, being the number of fatalities per accident multiplied by the event probability, is probably the one most frequently used. The charm of a single-valued acceptance criterion is certainly its relative simplicity. Simplicity, however, is not necessarily the hall-mark of truth. Recent industrial catastrophes have demonstrated convincingly that consequences *cannot* merely be expressed in terms of fatality numbers and that, consequently, a risk criterion *shall* not be expressed merely in terms of fatality rates. Also other consequence aspects, like *social*, *environmental*, *economical*, *political* and *cultural* aspects, to mention only a few, should be considered in the evaluation of risk bearing activities [4]. Moreover - and this is considered to be a major point of concern - a single-valued risk criterion offers the possibility to meet this criterion by reducing the *event probability*, leaving the "multi-aspect character" of the consequences unconsidered.

> *QRA, if used to as an tool to prove that a single-valued risk criterion can be met, must be considered as a vehicle for acceptance or introduction of all kinds of risk bearing activities which might be or should have been judged unacceptable for may be a number of other relevant reasons.*

It is particularly in case of Low Probability/High Consequence Risks that a single-valued risk criterion must be considered as inadequate. In those cases *risk reduction* should not be achieved by reduction of the *event probability*, but primarily by reduction of the *consequences* [5]. It is particularly in view of control and reduction of consequences that the potentialities of concrete structures will be discussed in this paper. This discussion is focussed on the potentialities of Prestressed Concrete Pressure Vessels (PCPVs) for storage of hazardous products to resist extreme thermal loads.

2. WHY PRESTRESSED CONCRETE PRESSURE VESSELS FOR STORAGE OF HAZARDOUS PRODUCTS

Accident statistics show an increase of the number of large-scale industrial accidents [4]. An evaluation of these accidents reveals, firstly, that in many cases storage vessels were involved and that, secondly, the failure of pressure vessels has often contributed significantly to the escalation of accidents into major catastrophes. The relatively low impact and fire resistance of traditionally built steel pressure vessels appears to be the main cause of these vessel failures [9]. Increasing the impact and fire resistance of pressure vessels would undeniably result in a reduction of the vulnerability of industrial facilities and hence in a reduction of the consequences and risks of large accidents. The high built-in impact resistance and insulating capacity of PCPVs would offer good prospects in view of enhancement of safety.
An example of a PCPV is shown in Fig. 1. The vessel is built of eight prefabricated segments. After these elements are brought in position prestressing tendons are installed in a stress-free state. The tendons are coupled at the "expansion" joints between the segments. At the inside of the vessel a tight liner is installed allowing substantial movements at the expansion joints. After installation of the liner the vessel is blown up until the strains ex-

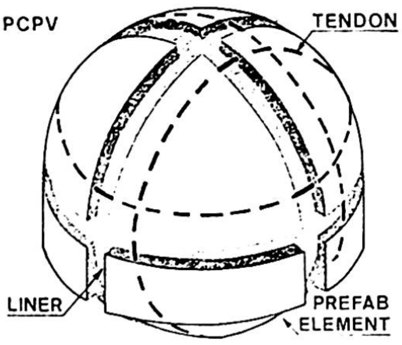

Fig. 1 Prestressed Concrete Pressure Vessel. Original concept after [3].

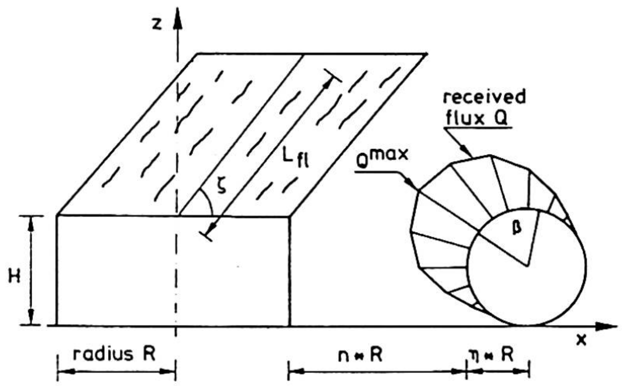

Fig. 2 Scenario of large-scale tank fire as considered by BOLCRYO [6].

erted in the prestressing tendons have reached the required design value. The expansion joints are then filled with concrete. After hardening of the concrete the pressure is relieved and the concrete is put in a stressed state. For a PCPV built according to just outlined procedure and which meets the test requirements for steel pressure vessels imposed by the Dutch Boiler Inspectorate the safety factor in the operational stage has been calculated at γ=2.8.

3. PCPVs UNDER FIRE LOADING AND ASPECTS OF THERMAL DESIGN

3.1 Fire scenario, heat flux and temperatures

For the determination of the temperature distribution in a spherical vessel a computer code called BOLCRYO has been used. In this code the influence of the emissive power at the flame surface, the relative humidity of the air, the wind velocity (flame inclination) and the surface characteristics of the target are accounted for. For the fire scenario sketched in Fig. 2 the radiation intensity Q^{max} received by a vessel and the associated temperatures in the concrete shell are shown in the figures 3 and 4. Wind velocity and tank distance are inserted as parameters. The tank distance is indicated by the tank distance factor n, being the distance between the sphere and burning (cylindrical) vessel divided by the radius of the burning tank. From Fig. 4 it can be seen that due to the cooling effect of the wind the maximum temperature does not necessarily coincide with the maximum flux. Temperature distribution over the thickness of the shell after 10 hrs is shown in Fig. 5.

3.2 Safety considerations

In case of *mechanical loads* (dead weight, live loads, etc.) structural safety

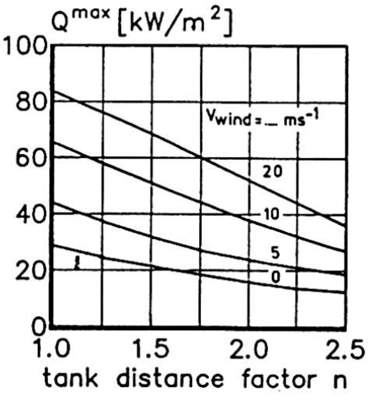

Fig. 3 Maximum heat flux Q^{max} received by a spherical vessel [6].

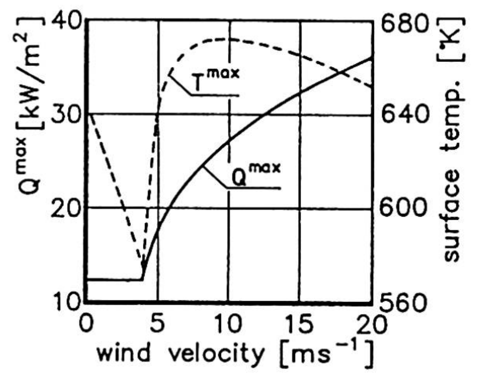

Fig. 4 Max. heat flux and surface temperature. Wind velocity as parameter.

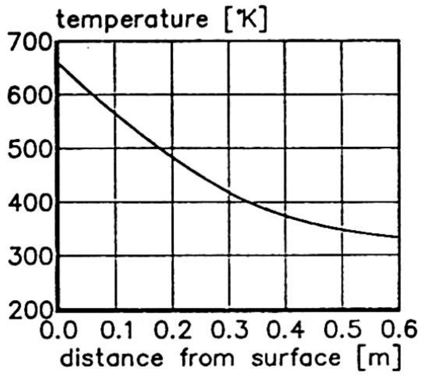

Fig. 5 Temperature distribution over the shell thickness after 10 hrs [6].

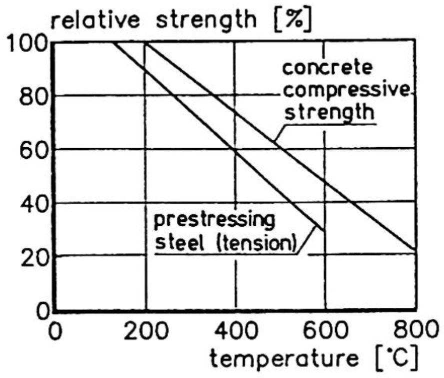

Fig. 6 Temperature dependency of concrete and steel strength (after [8].

is defined as the quotient of strength and load-induced forces, c.q. stresses. It is well known that in case of non-linear systems safety considerations shall take into account that local plastic deformations are acceptable as long as stability is guaranteed. This holds primarily for statically indeterminated structures but also, on cross-sectional level, for statically determinated systems. In sections where excursions in the plastic zone occur, the value of the *local* cross-sectional safety factor is $\gamma=1$!
When dealing with *imposed deformations* the failure criterion shall, in essence, be defined in terms of strains. In case of a combination of mechanical loads and imposed deformations both the strength and the strain criterion shall be checked. For *linear* and *brittle* systems (no yielding branch) the effects exerted by mechanical loads and imposed deformations can be added and compared with either the ultimate strength or the ultimate strain. Because of the linear character of the system both comparisons will yield the same safety factor. In case of *non-linear* systems, with either a plastic, a softening or a hardening branch, a comparison of the added effects of both types of actions with either the ultimate strength or ultimate strain does *not* give us reliable information about the actual safety. Adding, for example, the cross sectional forces caused by a mechanical loading and an imposed thermal deformation and comparing the summarized forces with the strength capacity will, in case of ductile systems, result in an *underestimation* of the actual safety, i.e. in a *conservative design* in so far as safety is concerned. This conservative approach is still proposed in the new EUROCODE 2. Bearing in mind its just elucidated shortcomings, the conservative approach will be applied now for judging, conservatively, the safety of PCPVs.under extreme fire loads.
In addition to foregoing considerations an evaluation of safety under thermal loads should take into account the *temperature dependency* of the material properties. The strength-temperature relationships of concrete and prestressing steel adopted in the present analysis are shown in Fig. 6 [8].

4. STRUCTURAL RESPONSE AND SAFETY OF A PCPV UNDER FIRE LOADING

For preliminary investigations of temperature-induced forces in a spherical vessel (3,000 m^3) a simple model was used as shown in Fig. 7. Two perpendicular rings of the sphere are considered, loaded by the internal overpressure caused by stored product (LPG: operating pressure ≈ 14 bar), and the external fire load. Because of the non-symmetrical character of the fire load the temperature induced deformations of individually expanding rings are not identical. To establish compatibility of deformations and equilibrium of forces two different concepts have been adopted [6]. In the first concept (I) compatibility and equilibrium are established by application of cross-sectional forces,

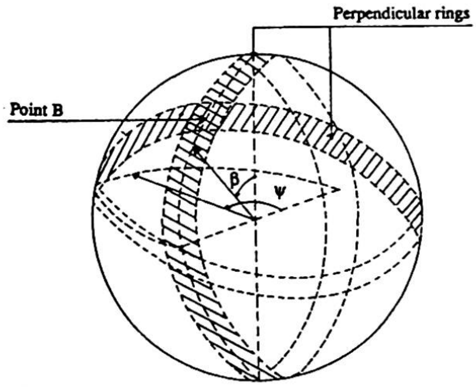

Fig. 7 Model used for preliminary investigations of the fire-caused forces [6].

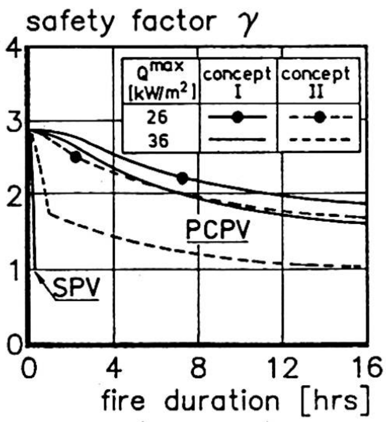

Fig. 8 Decrease of safety factor γ with fire duration. a) Steel vessel; b) Prestressed concrete vessel. (n = 2).

i.e. flexural moments, shear forces and normal forces at the point of symmetry, i.e. point B, of the rings. In the second concept (II) compatibility and equilibrium are achieved by application of fictitious, radially oriented distributed loads. In this concept high ring forces are exerted, viz. compression in the large ring and tension in the smaller one. In this way the occurrence of membrane forces in a non-symmetrically loaded sphere is simulated, albeit in a conservative way. The thus determined forces are added to the forces exerted by the stored product.
Of major interest in view of safety are the membrane forces. The calculated membrane forces divided by the temperature-dependent membrane strength of the rings yields the safety factor γ. The development of this safety factor with the duration of the fire is shown in Fig. 8. Two values of the maximum heat flux Q^{max} were considered, viz. 26 and 36 kW/m², the latter value simulating a very severe thermal loading. In Fig. 8 a comparison is made between the calculated safety factor of a steel pressure vessel (SPV) and a PCPV. A SPV would fail after about 10 minutes. This is in good agreement with experimental work of Droste and Schoen [7] and with what has been observed in a large number of industrial accidents. For a PCPV, submitted to the same fire loadings, the initial safety factor $\gamma = 2.8$ dropped to about 1.6 after 16 hrs, the safety factor being defined according to concept I. For the most conservative concept II a substantial increase in safety as compared to the steel pressure vessel was still found, even in case of the most severe thermal loading.
A more detailed analysis of the behaviour of the vessel under fire load reveals that the temperature induced forces hardly affect the actual safety of the vessel. The major reason for vessel failure is the temperature induced *decrease* of the strength of the load bearing prestressing cables.

5. PROBABILISTIC ANALYSIS OF DOMINO EFFECT IN A FICTITIOUS TANK FARM

The favourable structural behaviour of PCPVs under fire loads has been inserted in a probabilistic analysis of the probability of a catastrophic domino effect in a fictitious tank farm. The tank farm consists of twelve 3,000 m³ LPG pressure vessels and one 36,000 m³ double walled (steel/concrete) cryogenic tank. The spheres were considered to be built as either SPVs (wall thickness 37 mm) or PCPVs (wall thickness >600 mm). In total 24 initiating events and associated accident scenarios were considered, including rupture of piping, several BLEVEs (Boiling Liquid Expanding Vapour Cloud Explosions) and aircraft impact (Phantom II). The event probabilities were taken from open literature [9]. The results of the probabilistic analysis were compared with the results of a more phenomenological approach based on accident statistics [4,9].

The results of both the probabilistic and the phenomenological approach are summarized in Table 1. The probability of failure of one single SPV was calculated at 2.9 10^{-5}/yr and of a PCPV at 4.0 10^{-7}/yr. It is remarked that the probability of failure of one single PCPV is largely determined by the aircraft impact. The probability of a major domino effect involving all SPVs was calculated at 3.5 10^{-4}/yr. This figure was found to be in relative good agreement with the value obtained from the phenomenological approach, viz. 4.1 10^{-6}/yr. *No* realistic scenario could be compiled in which all PCPVs would fail catastrophically in one single accident!

Table 1 Probability of catastrophic domino effect in fictitious tank farm

Number of vessels n	probability of failure traditionally built steel pressure vessels		prestressed concrete pressure vessels
	phenomenological	probabilistic	probabilistic
1	3.6 10^{-5}/yr	2.9 10^{-5}/yr	4.0 10^{-7}/yr
12 (domino)	4.1 10^{-6}/yr	3.5 10^{-4}/yr	*incredible*

6. CONCLUDING REMARKS

One of the corner stones of risk reduction is consistent scenario thinking. Consistent and comprehensive scenario thinking teaches us that in case of Low Probability/High Consequence Risk the consequences of an accident might exceed acceptable limits. This makes that risk reduction should be achieved preferably, in some case *exclusively*, by reduction of the consequences *irrespective* of the event probability. Concrete protective structures, due to their built-in *passive safety potentials*, are most adequate for an almost deterministic control of consequences and, implicitly, for reduction of risks. As indicated in this paper PCPVs, because of their high built-in insulating capacity, substantially contribute to the reduction of the consequences and risks in large-scale industrial accidents. And this, as several independent studies have revealed, without an increase of the building costs [3,9].

REFERENCES

1. Waller R.A., et al., Low-Probability/High Consequence Risk Analysis, Plenum Press, New York, 1984, 571 p.
2. Foley G., The Energy Question, Pinguin Book, 304 p., 1987.
3. Bomhard H., Concrete Pressure Vessels: The preventive answer to the Mexico City LPG Disaster, IABSE, Versailles, September 1987.
4. van Breugel K., Concrete and the economy of hazard protection, 1st Int. Conf. on Concrete for Hazard Protection, Edinburgh, pp. 3-12, 1987.
5. van Breugel K., Concrete Structures for Consequence Control in Industrial Accidents, Sim. on Structural Design for Hazardous Loads, Brighton, 1991.
6. Asin M., Concrete Storage Vessels under Fire Loads (in Dutch), Delft University of Technology, Research Report, 81 p., 1990.
7. Droste B., Schoen W., Full scale fire tests with unprotected and thermal insulated LPG storage tanks, Journal of Haz. Mat., 20, pp. 41-53, 1988.
8. CEB-Bulletin 174, Model code for fire design of concrete structures, February 1987.
9. van Breugel K., Ramler J.P.G., Towards reduction of the vulnerability of multi-tank storage facilities, ICOSSAR '89, San Francisco, Vol. III, pp. 2189-2194, 1989.

Natural Draught Cooling Towers to minimise Adverse Environment Effects

Réfrigérants à tirage naturel pour réduire la charge sur l'environnement

Naturzugkühltürme zur Reduktion der Umweltbelastung

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SUMMARY
Thermal and nuclear power plants employ condensers for cooling the steam used for running the turbines and the condensers require large quantities of circulating water for effecting the cooling. Cooling towers are employed for recycling the hot water for repeated usage. The natural draught cooling towers (NDCT) have a lesser effect on the environment than the induced draught cooling tower.

RÉSUMÉ
Les centrales thermiques et nucléaires utilisent des condenseurs pour refroidir la vapeur qui entraîne les turbines; de ce fait, une énorme quantité d'eau en circulation s'avère indispensable pour refroidir les condenseurs. Les tours de réfrigération servent à recycler l'eau chaude et il est possible pouvoir ainsi la réutiliser maintes fois. Les aéroréfrigérants à tirage naturel exercent un moindre effect néfaste sur l'environnement que les réfrigérants à tirage induit.

ZUSAMMENFASSUNG
Konventionelle wie nukleare, thermische Kraftwerke benötigen zur Kondensation des abgearbeiteten Dampfes grosse Mengen Frischwasser. Kühltürme dienen der Wiederverwendung des aufgeheizten Kühlwassers in mehreren Durchläufen. Naturzugkühltürme haben geringere Auswirkungen auf die Umwelt als solche mit künstlicher Ventilation.

1. INTRODUCTION

Condensers in thermal and nuclear power plants require large quantities of water for cooling. If water is available nearby, it is used for cooling, otherwise cooling towers are used for recycling the hot water. For a typical 210 MW plant cooling about 33000 cu.m. of water per hour from 42.5 deg C to 32.5 deg C, the heat content discharged is about 3x10 to the power of 8 Kilo Cal/hour which will result in a thermal shock to the aquatic system of the water body.With increasing awareness of the damage caused to aquatic life by discharge of hot and possibly contaminated water into aquatic eco-systems and to minimise the requirement of water which would otherwise be required for human consumption/irrigation/aquiculture purposes, the cooling towers are becoming more common features of thermal and nuclear power plants in India. Of the two types of cooling towers normally used, the Natural Draught Cooling Tower (NDCT) has a lesser effect on the environment than the Induced Draught Cooling Tower (IDCT).

2. FEATURES OF NDCTs

2.1 Thermal Features

NDCTs have a tall hyperboloid-shaped tower on the outside and are majestic structures forming a landmark in any major power plant. They have a good aesthetic appeal and blend well with the other tall structures. There is some interrelation between the functional/thermal requirements and the structural form of the outer tower. For dissipation of heat the NDCT employs a simple process of evaporative cooling. Indian NDCTs are invariably of counterflow type wherein the water and cooling air move in parallel streams opposite to each other. Hot water from the condenser is sprinkled over a heat exchange medium or packing' or 'fill' arranged in the lower reaches of the tower. Cool air is drawn into the tower because of the difference in density between the hotter air inside and the cooler air outside and while passing upwards through the packing the air cools the water which is flowing down. Energy is required only for pumping the water into the condenser system after recooling and such energy expenditure is also required for the 'once-through' system .

The packing is of two types-film type employing PVC (or AC)corrugated sheets, or splash type employing PVC splash bars or concrete splash bars. The PVC film type packing of recent origin is more expensive and generally requires the use of treated water to avoid clogging of the finer pores of the packing. On the other hand the traditionally used splash packing in India employs a rugged system consisting of prestressed concrete splash bars called laths. This packing can handle practically any type of water and being of prestressed concrete, has a reasonably long life. In India so far the NDCTs were provided with splash type of packing.The concrete lath suits the Indian environment better in that it's production is labour-oriented and labour is inexpensive in India and needs employment opportunities. In a typical tower about 250,000 numbers of these laths of about 2.6M length may be required.

2.2 Functional Features

In the Indian towers hot water enters the tower at about 10M to 11M height above ground level, through mild steel headers and is then distributed throughout the area through concrete ducts and small diameter AC distribution pipes. Nozzles located below the orifices in the distribution pipes spray the water on top of the packing. Water cascades down through the layers of the packing in the form of fine droplets which interact with the upward stream of air, transferring the heat. The recooled water collects in a pond after it exits from the packing and is then pumped back into the condenser system. Various accessories provided for proper functioning of the tall NDCTs include inspection platforms and walkways,aviation warning lights,lightning conductor system, access staircase and ladders upto tower top, control gates and screens in the recooled water outlet, drainage system for the recooled water pond, etc.

2.3 Structural System

2.3.1 Outer Tower

The outer tower generally has a hyperbolic shape though nowadays other curvilinear forms are also used. This results in a highly efficient structural scheme for the outer tower. It is claimed that the outer tower has lesser material over the enclosed volume than an egg-shell over its volume. The minimum thickness of a 125 M tall tower can be as little as 175 mm. The outer shell is supported on a number of small diameter columns normally arranged in a diagonal manner. This open system of support columns forms the air inlet opening. These columns either rest directly on a foundation or rest on pedestals integral with the wall enclosing the pond of recooled water.

2.3.2 Internal System

Inside the tower the packing is supported independently over a grid of beams resting on a series of columns which rise up from the pond floor. These beams and columns generally are of precast reinforced concrete. Within the packing, the pear-shaped concrete laths are supported on bearer blocks or beams having serrations on the top face to hold the laths.

2.4 Construction Scheme

The outer concrete shell is constructed in a number of lifts of the order of 0.9m to 1.5m height, using a 'jump-form' system with a scaffolding system climbing on the already concreted shell in stages supporting the forms and working platforms. The climbing scaffolding is either moved up manually lift by lift or is hydraulically moved up in a mechanical system. In the lower regions where the diameter is large and shell thickness is more, the circumference is cast in a number of segments and higher up, where the concrete volume involved is small, concreting is done in two segments. To save on construction time the internal fill structure is precast and erected, generally after the shell construction is over. Current practice with the safer hydraulically climbing system is to start the erection of the fill structure simultaneously with the outer tower to save on time, adopting proper safety measures. The columns and beams of the fill-supporting structure are precast in a site casting yard and the laths are precast and prestressed by a long-line pretensioning method.

3. COMPARISON BETWEEN NDCT AND IDCT

As opposed to the NDCT, the IDCT employs mechanical means- a topside fan driven by a motor through a reduction gear box - to induce a draught of air to cool the circulating water.The primary advantage of NDCT is that its energy consumption is much smaller than that of an IDCT. Typically for a 210 MW thermal power plant about 1500 KWH of energy per hour is saved in the case of an NDCT. The NDCT has no moving or mechanical components and hence requires lesser maintenance. On the other hand the IDCT has a number of moving parts-motors, gear boxes,fans,etc. Regarding noise produced by the cooling tower, the NDCTs have a low noise level on account of falling water and the IDCTs have higher noise levels mainly on account of fan operation. Another important aspect affecting the environment is the drift. There is a tendency for the air passing through the tower to carry with it a 'drift' consisting of fine droplets of water. The moisture-laden exit plume is released by the tall NDCTs at a much higher elevation than the IDCTs and hence undesirable ground level condensation is minimised. The exit plume in an IDCT is discharged at lower levels and the consequent condensation on the structures around can cause a number of problems, especially for electrical installations. There are also problems of recirculation of the hot air back into the tower and resultant loss in efficiency.Under the Indian context the ambient air temperature is fairly high and hence the driving force on air movement for a NDCT is small and consequently the air velocity through the tower is small. The maximum loss of circulating water through such drift is less than 0.2% of the volume of circulating water. Hence drift loss is not significant and drift eliminators which trap the water drops in the exit plume are not required. On the other hand drift eliminators are a must for IDCTs. Drift eliminators account for a significant part of the pressure drop for the air moving through the tower. Since pressure drop directly affects the tower size or fan size, not having to provide drift eliminators results in savings. Since there are no moving parts in a NDCT, there is no need for any oil, grease or other lubricants which have a risk of contamination or pollution of the environment. The only two disadvantages of the NDCT are the high initial cost and the relative lack of flexibility for differential operation during various seasons. These disadvantages are far outweighed by the advantages.

4. POSITIVE INFLUENCES OF THE NDCT

4.1 Basic Features

The main positive feature of the NDCT is that it helps conserve water for purposes other than mere cooling, and there is no danger to the ecosystem by the discharge of large volumes of hot water into water bodies. The water requirement is limited to make-up water to compensate for drift loss or evaporation loss or blowdown to keep the concentrations of suspended/dissolved solids to acceptable levels. This requirement of make-up water is only of the order of 4% of the volume of circulating water. Since there is no consumption of extra energy, the use of NDCT promotes energy conservation. With the use of NDCT there is no noise pollution either. As mentioned earlier, the NDCT is an energy-saving and eco-sympathetic system.

4.2 Steps to Improve NDCT Performance

4.2.1 General

With further development of technology in India in the field of NDCTs, the performance of the NDCT is being improved with regard to three basic areas: thermal,functional and structural fields.

4.2.2 Thermal Aspects

In the field of thermal performance high-efficiency film-type packings are being introduced. The use of this type of packing results in smaller-sized towers and lesser energy for pumping the water into the tower/condenser system. The drawbacks of this type are that it generally requires treated quality water, it is relatively more expensive and its life has not yet been established in practice. The developing use of high-performance nozzles also results in better performance through better distribution of water over the

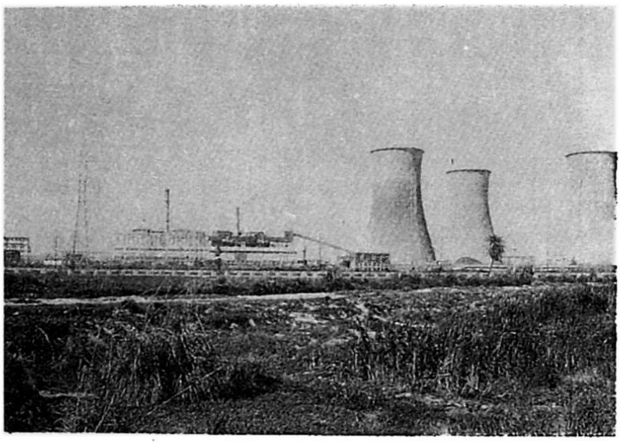

Fig.1 NDCTs in a power plant

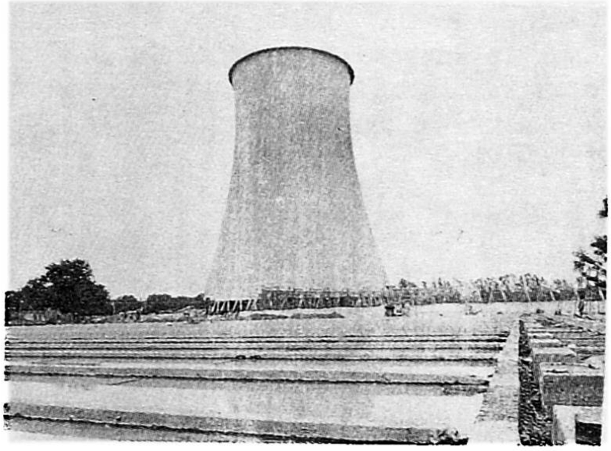

Fig.2 An NDCT with a lath casting yard in the foreground.

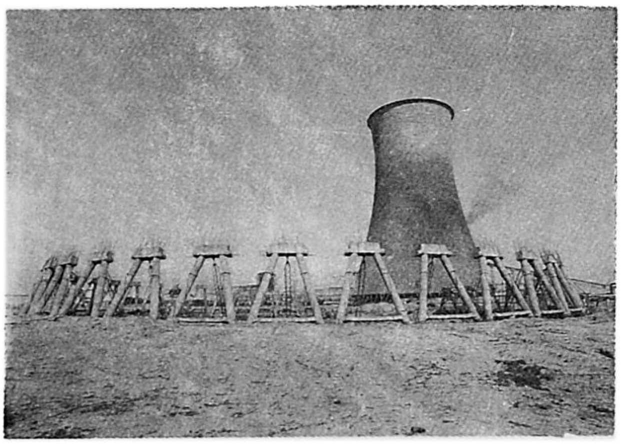

Fig.3 Precast diagonal column systems under erection

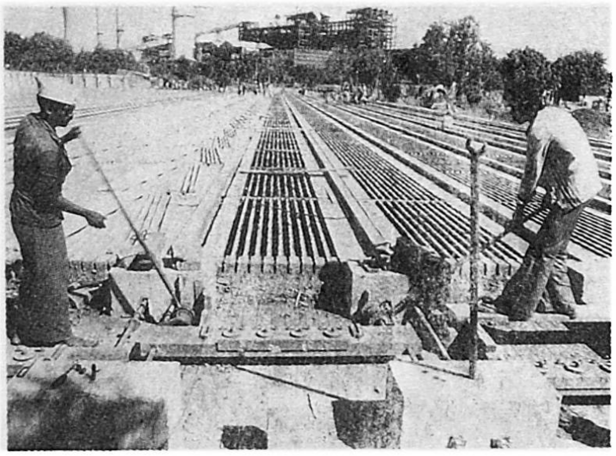

Fig.4 A typical lath-casting yard

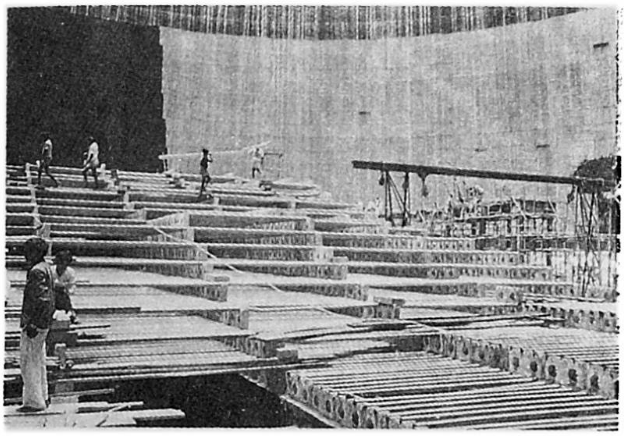

Fig.5 Assembly of laths for the packing in progress

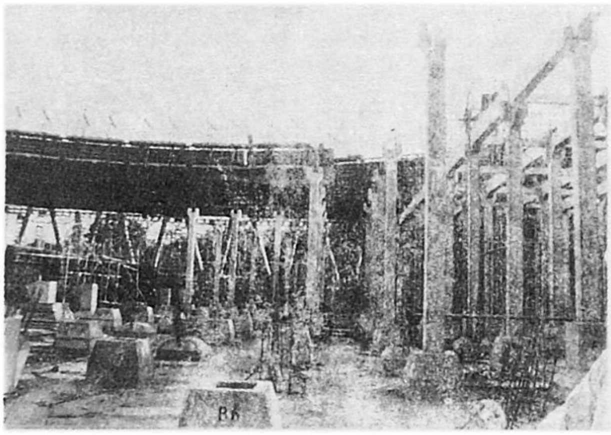

Fig.6 Hydraulically climbing form in position.

packing and finer atomisation of water to promote heat transfer. The recent development of 'dry' type of NDCT has not yet found an application in Indian power plants because of the high cost. In this type the circulating water is fully enclosed in heat exchanger pipes and there is least loss of water. The impact on the environment in this case is even less than that of the 'wet' type of NDCTs.

4.2.3 Functional Aspects

A number of measures are being taken to improve the functional performance and efficiency of NDCTs with reference to operations and maintenance. The various accessories mentioned earlier are being improved upon. Maintenance is being planned for in the design stage itself. In France water collecting systems have been recently developed to collect the recooled water just below the packing itself and thus saving on precious pumping head. This system has been installed in the world's tallest NDCT at Golfech. In some NDCTs in Germany flue gas is being vented through NDCTs thus obviating the need for a separate chimney. Such systems have not yet found an application in India.

4.2.4 Structural Aspects

Better understanding of the behaviour of the outer hyperbolic shell,development of better analysis and design techniques-particularly with reference to buckling phenomena,response to dynamic loads and thermal loads and soil-structure interaction- and development of better structural forms for the internal fill-supporting structure are some of the developments in the structural field in India.On the construction side, indigenous adaptation of the hydraulically-climbing form and more efficient assembly of the internal precast fill-supporting structure are some of the developments. Construction periods are getting reduced and construction is being more streamlined.Better quality control measures and Quality Assurance Schemes are being implemented.In France vertical columns have been recently introduced for supporting the shell instead of diagonal columns, as for instance in the NDCT at Golfech, to simplify construction and to improve the thermal performance.

5. CONCLUSION

Given the requirement of power generation and consequent requirement of cooling of condenser steam, the Natural Draught Cooling Tower is the most suitable system from the point of view of least adverse effect on the environment. There are a large number of such towers in India which are operating well and these towers are being continually improved. The Indian industry has now geared itself up to meet the future challenges of power production by building up an indigenous base for the design and construction of the NDCTs.

REFERENCES

1. RAGHAVAN N., GANAPATHY K., ALIMCHANDANI C.R.,Design and Construction Aspects of some Natural Draught Cooling Towers in India. 3rd International Symposium on NDCTs. IASS Paris 1989

2.DESRUMAUX M., The world's Largest Cooling Tower, National Seminar on CTs, New Delhi.1990

3.RAGHAVAN N., ALIMCHANDANI C.R., Recent Developments in the Structural Design Aspects of NDCTs,National Seminar on CTs, New Delhi. 1990