fib-news
CEB•FIP

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June 2003

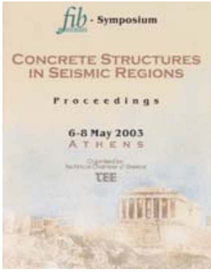
fib 2003: Great days in Athens

Michael Fardis (Chairman OC) and Honorary President Theo P. Tassios (Chairman SC) at the closing of the symposium

More then 500 participants from 47 countries attended the 2003 *fib* symposium on Concrete Structures in Seismic Regions held on 6–8 May in Athens, Greece. The organising committee, chaired by Prof. Michael Fardis, had to overcome some rather detrimental effects on attendance such as the war in Iraq and the SARS epidemic. However, all this could be left behind when the symposium participants were finally welcomed on Tuesday morning by A. Kotzambasakis, Vice-President of the Technical Chamber of Greece, in the magnificent Athens Concert Hall Megaron. Very appropriately in these surroundings, the opening session started with a trio playing a much appreciated music programme with pieces by Theodorakis, Elgar, Gardel and Hatjidakis. President Jim Forbes then opened the symposium, and later proceeded to honour the 2003 *fib* medallists Paolo E. Pinto and Steen Rostam (see separate report in this issue).

During the next three days approximately 170 papers were presented in three parallel sessions. Poster sessions allowed the introduction of another 40 papers. A special session, and a well organised technical tour on Friday, focused on the Rio–Antirio Bridge, presently under construction near Patras, Greece. The exhibition area accommodated 22 commercial exhibitors and also offered booths for *fib* and IABSE, who were supporting the symposium. A marvellous welcome reception on the Monday evening and an unforgettable open air banquet in a Byzantine estate overlooking the city of Athens delighted the 150 or so accompanying people (should it be mentioned that all the week the weather with a excellent—29 °C and a light breeze)?!

On the Sunday preceding the symposium, the *fib* Council and Steering Committee met, and in the evening enjoyed a common dinner with the members of the IABSE Executive Committee (also meeting in Athens), on invitation by the organising committee. The same day, in parallel, saw the opening of a well attended two-day *fib* course on Strengthening with Externally Bonded FRP Reinforcement (see separate report in this issue). The Technical Activities Workshop on Monday, immediately preceding the symposium, offered a unique opportunity to discuss some issues of the preparation of the next Model Code and follow up on the invited lectures of the winners of the 2003 *fib* diplomas (see separate report in this issue).



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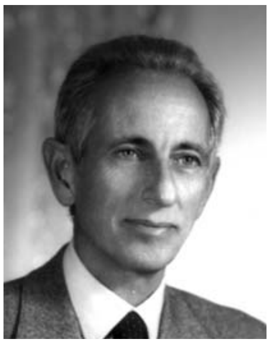
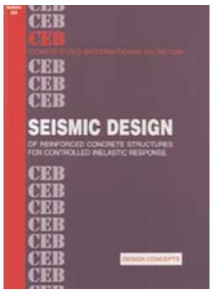
fib medals of merit for Paolo Pinto and Steen Rostam



On Tuesday 6 May 2003, during the opening ceremony of the 2003 *fib* symposium on Concrete Structures in Seismic Regions, in Athens; President Jim Forbes honoured two *fib* medallists.

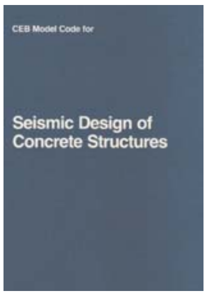
The first (alphabetically), was conferred on **Paolo Emilio Pinto**. Born in Rome in 1940, he became Professor of Structural Engineering in the Department for Structural Engineering and Geotechnics at the Universitá La Sapienza in Rome in 1975, and has held the chair of Earthquake Engineering ever since. This was the first chair on this discipline established in Italy, in conjunction with one at the Politecnico of Milan. He had cultivated this discipline since his final university years, and since then, it has remained the central magnet of his scientific and professional interest in most of its many facets. He has written more than 200 papers in the related fields of behaviour, modelling and design of concrete structures under seismic loading and probabilistic risk assessment. Currently, he is putting the finishing touches to a book entitled *Seismic Reliability Analysis of Structures*, due to be published by the end of 2003.

The first important subject of his scientific research was the modelling of behaviour and analysis of the non-linear response of RC structures. An early paper published in 1973, co-authored with M. Menegotto entitled '*Methods of analysis for cyclically loaded RC plane frames including changes of geometry and non-elastic behaviour of elements under combined normal force and bending*', was presented at the IABSE Conference in Lisbon, and is considered to have initiated the now-standard 'flexibility-based' methods for non-linear analysis of RC structures. Subsequently, in his years of activity within the CEB, his expertise in the area was set to use with the creation of the so-called Special Task Groups, which he chaired for a number of years from the mid-1980s to the mid-1990s. The purpose of these groups was the production of S.o.A. reports on various aspects of non-linear behaviour, analysis and design of RC structures, the last of which collects a series of recent advances from an international group of experts and was published in 1998 as CEB Bulletin 240 (entitled *Seismic Design of RC Structures for Controlled Inelastic Response).*



Another and perhaps the most characteristic area of his work lies in probabilistic methods for reliability assessment of structures: this type of approach is a constant feature in his treatment of seismic problems in all kinds of applications—buildings, bridges, dams, nuclear power plants and infrastructures. Having been introduced to this fascinating viewpoint by Julio Ferry Borges, a pioneer of probabilistic treatment of structural safety and long-time President of CEB, he admits to always feeling in debt to this outstanding researcher for the example he set and the many forms of encouragement received.

The third main area of his activity is the challenging and sometimes unrewarding task of producing design codes (specifically seismic design codes). He has been involved in this 1979, when the CEB asked him to coordinate a group of leading international experts from Europe, the USA, New Zealand and Japan in order to write what would later become the CEB Seismic Model Code, the final version of which was issued in 1983 as CEB Bulletin 165. This document, introduced for the first time in Europe the (by then advanced) concepts of force-reduction factors and capacity design. Subsequently, when the European Commission decided to launch the Eurocodes, he was called upon to work on EC 8: *Seismic Design* and, after the reorganisation that took place in 1990, he was designated Chairman of the sub-committee in charge of EC 8. He held this position until 1998, having finished the ENV drafts of the six parts of EC 8: buildings; bridges; towers; tanks; foundations; and strengthening and repair.



From 1985 to 1991 he chaired the General Task Group on behaviour and analysis of reinforced concrete structures under alternate actions that produced CEB Bulletins 210 and 230, and from 1991 to 1998 he chaired the CEB Commission 3: *Design*, also acting as convenor of its Task Group on seismic design. In 1998 he was appointed by the Council as Chairman of *fib* Commission 7: *Seismic Design* and as such is an *ex officio* member of the Steering Committee.

Paolo E. Pinto is not only engaged as a member of national and governmental commissions in the field of seismic design; he also has numerous international involvements as an invited lecturer, organiser and editor of major international symposia on seismic design of bridges, and runs a consulting activity that includes the seismic safety assessment of about 2500 existing bridges in the national highway system, the national electric power network and the revision of the seismic design for the Messina Strait Crossing Bridge.

From this curriculum vitae it becomes clear that to honour Paolo E. Pinto in conferring this *fib* medal of merit, no more appropriate event could have been chosen than a symposium on seismic design issues.


Messina Strait Crossing Bridge

The other recipient was **Steen Rostam.** Born in 1943, he graduated in 1969 from the Technical University of Denmark, from where he also obtained his PhD in Structural Engineering in 1977. He then became a part-time Associate Professor from 1978 to 1990, lecturing on bridge design and construction at the same university.

The rest of the time he was with COWI Consulting Engineers and Planners AS, Denmark, since 1973 and since 1990, is a full time chief engineer for concrete durability technology, being active in rehabilitation and service life designs in the Middle East, Eastern Europe, Russia and South America. He has also held specialist courses and workshops, and gave keynote lectures worldwide. Just to mention a few of them: in 1983 he organised the first CEB-RILEM International Workshop on Durability of Concrete Structures in Copenhagen (photo); co-organised (with Peter Schiessl) the second one in 1986 in Bologna, lectured to the IABSE short course on Durability of Structures in Lisbon 1989, and organised multiple 1–5 day courses in the Middle East, Australia, Norway and Brazil.


Steen opening the 1983 Copenhague Workshop in presence of the late Troels Brøndum-Nielsen


Great Belt Bridge, Denmark

Among many other things, he was responsible for the durability and 100 years service life design concept for the Great Belt Link in Denmark. There, he introduced epoxy-coated reinforcement using a fluidised bed dipping technique for three-dimensional fully-welded reinforcement cages for the bored tunnel lining segments. Service life design was followed-up with the installation of a total of 480 corrosion sensors.

He has been active in the CEB since 1973, chairing General Task Groups and Commissions and as such, co-authoring substantial publications in the field of durability, maintenance and repair, among them contributions to the CEB-FIP Model Code 1990, Workshop Reports and the CEB Design Guide: *Durable Concrete Structures* published by Thomas Telford (photo). From 1991 to 1998 he chaired the CEB Commission 5: *Operation and Use*. From 1998 until 2006 he is Chairman of the *fib* Commission 5: S*tructural Service Life Aspects* and as such is an *ex officio* member of the Steering Committee.

Congratulations to both *fib* medallists!


Medallists after the award ceremony (from left to right: Steen Rostam and his wife Britta, President Jim Forbes, Paolo E. Pinto)

fib diplomas 2003 in honour of Carlo Cestelli-Guidi

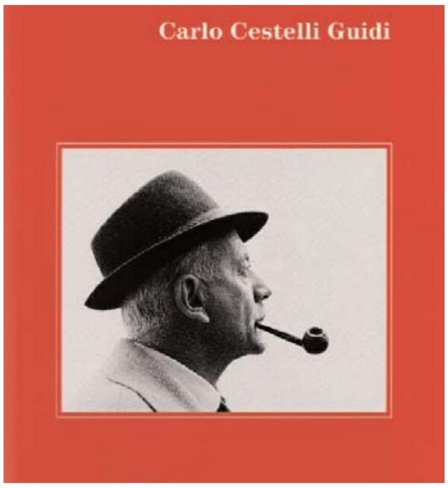
On Monday 5 May 2003, during the Technical Activities Workshop, the 2003 diplomas were awarded. As reported in *fib*-news in September 2002, the so-called '*fib* diploma to younger engineers' is given every two years at the official *fib* symposium. The award is given separately in two categories—*Research* and *Design and Construction* and consists of a diploma, prize money of 2000 CHF, and a free invitation (including travel and accommodation support) to the *fib* symposium. The prize money for the 2003 award was sponsored by AICAP (Associazione Italiana Calcestruzzo Armato e Precompresso) in memory of the late Prof. Carlo Cestelli-Guidi (1906–1995), the former President of the Comité-Mixte CEB-FIP, FIP Honorary Member and FIP Medallist 1988, an eminent Italian researcher and designer in the field of prestressed concrete, geotechnics and foundations.

The Steering Committee appointed an international jury of seven members:

- Prof. Julio Appleton (Portugal),
- Prof. György Balázs (Hungary, chairman of the jury)
- Prof. Konrad Bergmeiser (Austria)
- Dr Hans-Rudolf Ganz (Switzerland)
- Hon. Pres. Jan Moksnes (Norway)
- Prof. Hajime Okamura (Japan)
- Prof. Joost Walraven (Netherlands).

Proposals could only be submitted by *fib* National Member Groups who pre-selected the best candidates from their countries.

Happy winners of the 2003 *fib* diplomas (from left to right: Stefano Pampanin, Giuseppe Mancini (Deputy-President), Jim Forbes (President), Anne Beeldens, Giorgio Macchi (Head Italian Delegation), Marco Menegotto (Italian Delegate for AICAP), Cees Blom, Luis Cancio Martins, György Balázs (Chairman of the Jury)



The jury evaluated 16 submissions from 11 countries judging the works'

- technical or scientific level
- importance
- innovation or scientifically new results
- general impression.

Its task was difficult due to the high standard of almost all of the submissions. The jury's final decision was to allocate two first places in both categories and to give an additional special mention as follows:

The winners in the *Research* category are

- Stefano Pampanin (Italy),
- Cornelis B. M. Blom (The Netherlands)

with a special mention to

- Anne Beeldens (Belgium).

The winners in the *Design and Construction* category are

- Stein Atle Haugerud (Norway)
- Luis Câncio Martins (Portugal).

In view of the splitting of the prizes, the sponsor generously increased the prize money to 1000 Euro each (instead of Swiss Francs). In addition, a monograph on the life and work of Carlo Cestelli-Guidi was given to all participants in the workshop. The winners and the special mention gave excellent presentations of their work that will be published in *fib*-news.

Design philosophy of concrete linings for tunnels in soft soils

Cees B. M. Blom*
Holland Railconsult /
Delft University of Technology

*The author is one of the winners of the *fib* 2003 diplomas to younger engineers in the *Research* category. The photo shows him in Athens receiving his diploma from the President Jim Forbes, with Marco Menegotto and Giorgio Macchi from the sponsoring Italian Delegation standing behind.

Born in 1972, C. Blom finished his PhD thesis in 2002 at the Delft University of Technology. This paper summarises his thesis, using the same title, and served as basis for an excellent presentation during the Technical Activities Workshop in Athens.

Introduction

In December 2002 a PhD thesis entitled 'Design philosophy of concrete linings for tunnels in soft soils' was published at the Delft University of Technology [1]. This article is based on the contents of this thesis.

In this thesis a new analytical model is developed for describing the structural behaviour of segmented concrete linings of shield driven tunnels in soft soils. New elements in the model include the explicitly implemented longitudinal joint behaviour and the ring interaction between adjoining rings. In addition to this, a new load model is developed which takes into account the injection pressure of grouting (Figure 1) during the assembly stage of the tunnel. The new developments make it possible to analyse the structural behaviour of the lining during the assembly stage, which was previously barely possible.

Observations, measurements and research shows that the adoption of 'tunnel' knowledge from foreign countries with different soil conditions needs special attention. In these cases, it was found that observed lining behaviour showed discrepancies with the predicted behaviour. One particular issue was clear very early: it transpired that the assembly (Figure 2) of the lining has a dominant influence on the delivered quality of the lining of tunnels.

More than a decade ago the Dutch Government decided that shield driven tunnels have a high potential in the crowded Dutch area. To the domestic Dutch construction market this construction method was totally new, and neither guidelines nor regulations were available. Analysis of the construction method in foreign countries

Figure 2. The full-scale tunnel test facility at the Delft University of Technology in the Netherlands. The facilities diameter and height are 16 m and 6 m

delivered a tremendous amount of experience and knowledge; however, there was a crucial difference with the Dutch circumstances: the soft soil conditions and high water tables in the Netherlands. This means that a technology would be applied outside its proven applicable boundaries. The Government understood the risks that were involved and two experimental projects were set up. From these two projects the Dutch construction market had to learn to construct shield driven tunnels, in soft soil conditions with high water tables.

The thesis began after some years of experience with design and measuring the behaviour of shield driven tunnels. This experience demonstrated that structural analysis of the assembly of the lining is barely regarded in the design now, whereas practice demonstrates the need for adequate tools for the analysis.

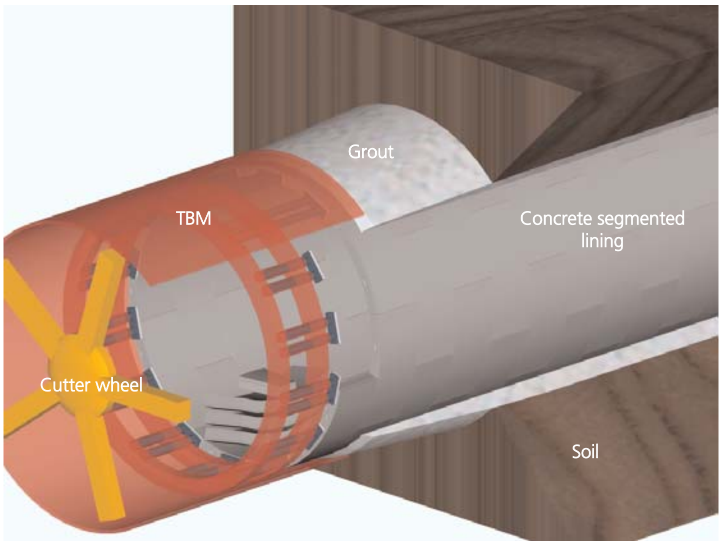


Figure 1. Illustration of the Tunnel Boring Machine (TBM), the lining, the grout, the soil and the assembling stage

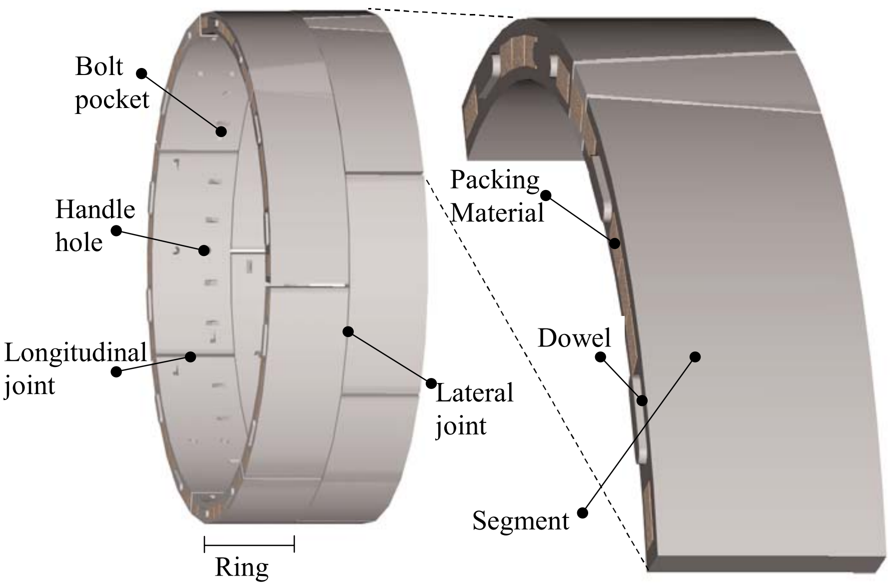


Figure 3. Tunnel lining definitions

The thesis analyses what the assembly of the lining means in terms of structural behaviour and how it should be taken into consideration in the design and construction as well as the exploitation stage of the tunnel.

Earlier research involved very advanced three dimensional (3D) FEM analyses of the tunnel behaviour during the assembly. To validate these models and to validate the hypotheses made for the effect of the assembly it was decided that full-scale tests on real tunnel linings should be carried out (Figure 2). These tests took place at the Delft University of Technology. The testing facility was specially designed to simulate the process of the assembly of the tunnel. Apart from the full-scale laboratory tests, field measurements were also made for additional consideration.

Using interviews with experts on actual shield driven tunnel projects, a profile was drawn up of experiences with recent projects. This knowledge helped to define the outline of the research program.

A new analytical model is described for the behaviour of tunnel rings with lateral couplings between adjoining rings and explicitly implemented longitudinal joint behaviour (Figure 3). Analyses using models and frame analyses were carried out in order to determine the relationships between input parameters as load and the deformations and internal forces in the segments.

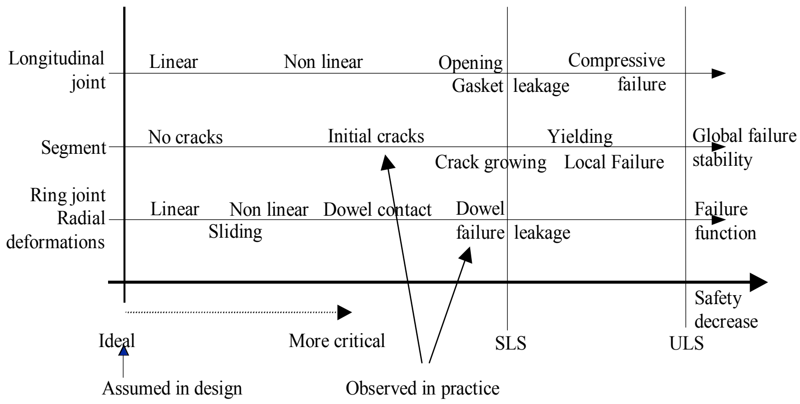
Structural models make use of load models. In this thesis some load models are described that are used in practice. Besides that, a new load model is developed that involves the load due to grouting at the assembly stage. The main advantage of this model is that it can easily be used in a relatively simple frame analysis of the lining for example. The new analytical model is calibrated using the full-scale laboratory test results and the field measurements at the Botlek Railway Tunnel and the second Heinenoordtunnel in the Netherlands. The comparison shows a good agreement between the new model and the measurements.

Analyses of the assembly practice show that basic assumptions often made in design are not supported by practice. It is shown that deviations of the basic assumptions made can easily result in a loss of quality of the delivered tunnel (Figure 4). The thesis demonstrates that the assembly is a very complex phase in the lifetime of the tunnel. It transpires that design choices can heavily influence the loss of quality in the assembly. The much-improved insight into assembly is a spin off for a more economical optimised lining design.

Problem description

It becomes clear that a collective problem in practial projects is the loss of quality during the construction of the lining, by cracking of and damage to the concrete segments (Figure 6). The available structural engineering models do not provide tools to analyse the damage mechanisms that occur during the assembly. This is actually a result of the wish to design the lining with the requirements for the serviceability stage as governing; therefore the basic assumption is that the assembly stage should be non-governing. However, practice shows that the assembly stage is very important with regard to eventual loss of quality.

Figure 4. The lining safety development. The 'ideal' situation assumed in the design and the 'observed' situation in practice during the assembly



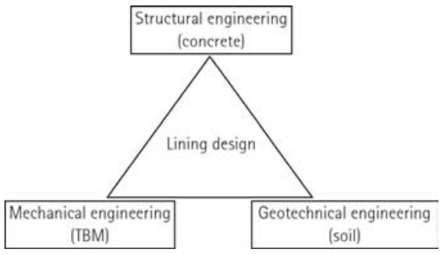


Figure 5. Three disciplines in the lining design

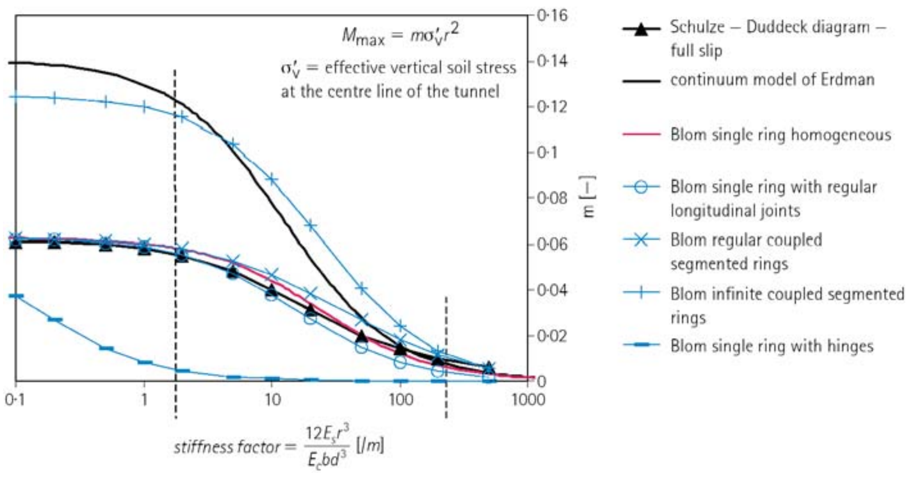


Figure 7. Comparison of the maximum tangential bending moments for the new analytical solution and solutions from literature

It is obvious that quality loss due to cracks and damage mainly occurs during the construction of the lining. In the tunnel boring machine (TBM) the segments are erected to form a ring. The TBM is a very advanced machine designed by specialists in the field of mechanics and machinery. Specialists in the field of civil engineering design the lining. Both disciplines interact with geotechnical engineering (Figure 5). It might be a coincidence that the quality loss occurs at the contact interface of these two specialist fields. On the other hand it is questionable whether or not both disciplines sufficiently communicate with each other in order to optimise design and construction.

The objective to clarify assembly of the lining

The objective of the thesis is to analyse the behaviour of the lining in the assembly. From this analysis it becomes clear why the assembly is so important. The dominant parameters that influence the lining behaviour are determined. Models are analysed to determine the behaviour they describe.

Figure 6. Photograph of observed damage

Additional mechanisms are determined that are basically not implemented in common design models.

The described models and mechanisms are validated with measurements from the full-scale laboratory tests at the Delft University of Technology, measurements from the Botlek Railway Tunnel and measurements from the second Heinenoord Tunnel.

Consideration is given on how the design and the construction of the lining should involve the assembly.

Analytical models

In literature on this subject, many models are published to analyse the behaviour of the lining of shield driven tunnels. These analytical solutions generally only involve a single ring, mostly without explicit consideration of the rotational stiffness of the longitudinal joints.

In this thesis a new approach is described on how to implement explicitly the rotational stiffness of the longitudinal joints and the lateral interaction between the rings for a lining system in an elastic soil continuum. The new analytical solution for the segmented linings of shield driven tunnels, with explicitly integrated longitudinal joints, lateral ring joint interaction and elastic soil continuum offers a very powerful tool to calculate the lining behaviour in the serviceability limit state. The solutions provide a transparent understanding of the influence of parameters and structural design values such as internal forces and deformations. It also shows that non-linear behaviour of the longitudinal joints can be implemented in the analytical solutions.

A comparison of the new analytical solutions with well-known solutions from the literature shows good agreement (Figure 7). Since the solutions in the literature were never presented for single rings with explicit longitudinal joints and coupled systems, such a comparison can not be made. However a direct comparison for the single homogeneous ring is made and agrees very well. The explicit implementation of the longitudinal joints and the lateral coupling demonstrates the influence of these geometrical parts of the lining.

One has to be reminded that the predicted forces and the deformations are based on the so-called 'beam' analysis. This means that the force distribution over the segmental width is assumed to be the average value over that width. It turns out that the distribution (especially important in crack analysis) of the stresses is not equally distributed over the segmental width.

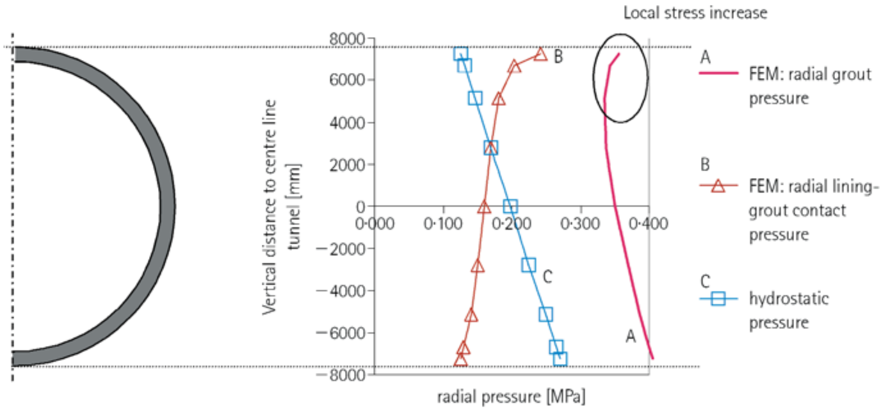


Figure 8. The radial pressure of the several loading components of the grout. The resulting grout pressure (A, radial grout pressure) is the issue of the new 'uplift loading case'.

Loading and ultimate limit state (ULS)

Attention is given to load cases in the serviceability and at the assembly stages. In this thesis, an additional load case (the 'uplift loading case') is presented to invoke the consequences of poor support that might occur during the construction stage. Analyses of FEM models of grouting result in the uplift loading case, which is a load model that can easily be used in the lining analyses (Figure 8). It shows that structural analyses of linings with full soil support (ring analyses with soil support in the serviceability stage) do not confirm the applied lining thickness that is observed in current practice. From the structural ring analyses with full soil support it follows that the application of thicker linings has a poor influence on both safety and cost (Figure 9). The uplift loading case (which involves grout loading on the lining in the assembling stage) shows that the soil support has a major influence on the safety of the lining and that therefore the grout material specification and pressure should be considered very carefully.

The structural analysis of the lining includes the question as to what the actual ULS of the lining means in relation to the acting forces. Geometrically and physically linear and non-linear analyses show that the geotechnical structure of the lining in soil requires an alternative approach for the ULS. The ULS is not reached by the excess in tangential bending capacity of the lining and radial deformations, but more-so by the excess in normal force capacity of the lining. Two additional failure mechanisms are distinguished: local buckling and snap through. These mechanisms should also be checked when analysing the structure for the ULS.

Models compared with measurements

A comparison is made between the new analytical solution and the results of the full-scale tests carried out at the Delft University of Technology. Two main cases are considered: the-all-in-one test and the sequential loading test. In the all-in-one test, the total system of three rings is loaded in the radial and axial directions at the same time. In the sequential load case in the first instance only two of the three rings are loaded in the radial direction. In the second instance the third ring is loaded in the radial direction in the presence of axial forces (Figure 10).

The results of the analytical solution for the loading-at-once case are consistent for the radial deformations and the tangential stresses. The analytical solution is fully confirmed by the results from the laboratory test in this case.

The comparison with the sequential loading case involves some complications. It is concluded that the loading of a ring results in redistribution of the acting forces when ring interaction can occur. In the case of the full-scale test, approximately 60% of the acting loading migrates to adjoining rings. The direct adjoined ring dissipates 40% of the acting loading, while the next adjoining ring dissipates 20%. These values are confirmed by 3D FEM analyses. Furthermore it transpires that only ovalisation loading migrates through the lateral joints. The uniform pressure does not migrate. As a consequence the loading in the analytical model is adapted to this migration hypothesis.

With particular consideration of the migration of acting forces, the results of the sequential loading in the full-scale testing can be compared. The results of several types of calculation models, such as analyt-

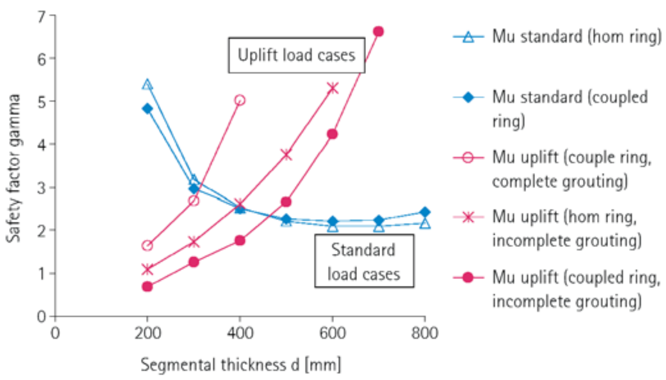


Figure 9. Safety factor development as a function of the segmental thickness. The 'Standard load cases' are ring analyses with soil support in the serviceability stage. The thicker the lining, the lower the safety. The 'uplift load cases' involve the grout loading at the assembly

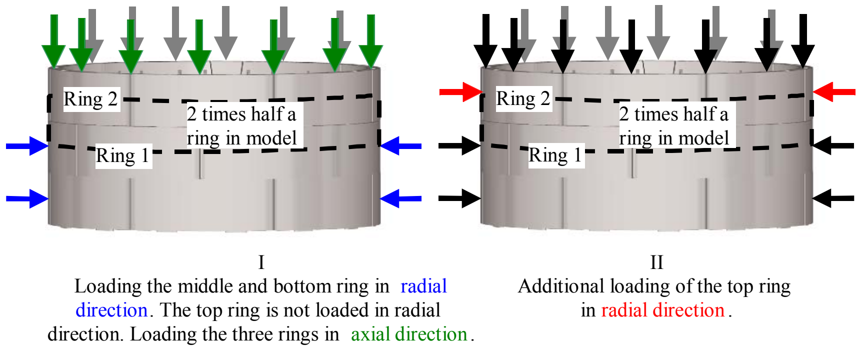


Figure 10.The loading order in the full-scale test due to the case of the sequential loading

ical solution, frame analysis and 3D FEM analysis, show very good agreement with the measured values in the full-scale test.

The analysis shows that the subsequent loading influences the deformations and the internal forces in the adjoining rings. The lateral joint interaction capacity is very important from this point of view. It transpires that due to the sequential loading, the integrated forces in a ring are not influenced by the coupling forces; however, locally the coupling forces will result in highly disturbed stress spots.

A comparison is made between the results of the calculations and the measurements of real tunnel linings in practice. This comparison is focused on the tangential components of the internal forces. It becomes clear that the influence of the axial forces on the tangential components is especially visible in the tangential stresses and the tangential normal forces. The contribution of the axial forces to these tangential components is established by the involvement of the lateral contraction. The tangential bending moments do not show this influence; nevertheless, the influence of the couplings in the lateral joints is visible.

Figure 11. Installation of a instrumented segment at the Botlek Railway Tunnel to measure assembling stresses

The comparison of the calculated results with the measurement data of the Botlek Railway Tunnel (Figure 11) gives the conclusion that the uplift loading case with incomplete grouting has occurred. The comparison of the tangential stresses, the tangential normal forces and the tangential bending moments is consistent with the calculation results based on the incomplete grouting in the uplift loading case (Figure 12).

From the measurements it becomes clear that tangential stresses are not uniformly distributed over the segmental width. An analysis of several stages in the assembly shows that the distribution of the tangential stresses is highly non-uniform, especially when the ring is within the TBM or just leaves the rear of the TBM. This is of particular interest when crack analyses are carried out. It is also observed that in these stages amplitudes of values occur which exceed the values in later stages.

The comparison of the model results with the measured data at the second Heinenoord Tunnel yields the conclusion that the load conditions at the assembly should be due to the uplift loading case with complete grouting or solely the normal loading case without the tangential components. It is obvious that the internal forces in the lining develop in time.

Damage mechanisms

The goal of the ideal assembling process is to build a perfectly round ring without any initial stresses, well-closed joints and equal supports of all segments. Design of the segments and ring layout are intended to produce a perfect system of segments with a perfectly circular shape of the ring. It becomes clear that there are many causes that might result in a loss of quality (Figure 13). The causes might result in a loss of quality by themselves, but the causes might also act simultaneously.

Examples are given of mechanisms that contribute to the stresses in the segments. These mechanisms are mostly not implemented in the ring models. Therefore additional analyses have to be carried out to analyse these mechanisms. It turns out that the additional mechanisms might result in

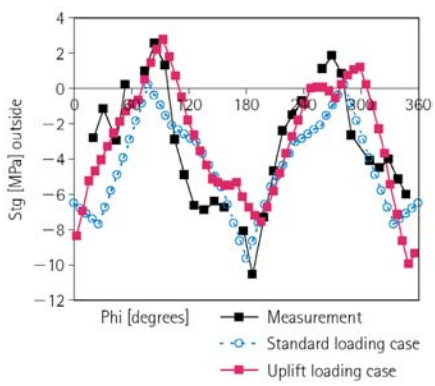


Figure 12. Comparison for tangential stresses in a tunnel ring between measurements, calculations with the 'standard loading case' and calculations with the 'uplift loading case'

Figure 13. Examples of irregularities in the segmental supports. Uneven supports might cause cracking.

high tensile stresses that cause cracks in the concrete. The mechanisms result in the crack direction often observed in practice (Figure 14). The mechanisms, mostly 3D problems, give the understanding as to why cracks occur so easily during the assembly of the lining. Since these mechanisms easily result in cracking, the best solution is to avoid the occurrence of the mechanisms. Main driving forces for the cracks are torsional moments, additional tangential moments, shear forces and high axial forces.

Design philosophy

The design approach should always have the boundary condition that the serviceability stage is normative. To fulfil this condition basic assumptions are made in the assembling stage. It has to be proved that these basic assumptions are valid in design, construction and exploitation. In the case that the assembling stage is at least as normative as the serviceability stage (in respect to the lining), an optimum economical loss occurs because the assembling stage is only a minor period in the lifetime of the lining.

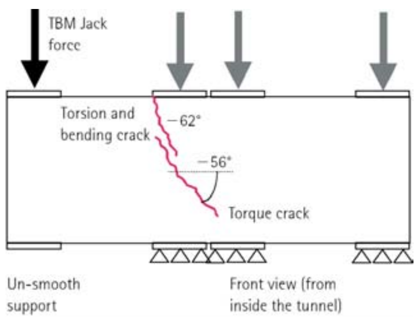


Figure 14. Crack spots and directions due to bending and torque as a result of uneven segmental supports.

A design philosophy is described that includes the analysis of the lining behaviour at the assembly. The optimal design is actually as follows:

- The lining is designed in the serviceability stage without any consideration of the assembly.
- The construction method is consequently determined such that it does not result in any aggravating addition to the serviceability stage.

The extended analyses in the thesis contributes to the necessarily fundamental understanding of the structural behaviour of the segmented lining of the tunnel in both assembling and serviceability state. The understanding of the structural behaviour is the basis of the identification, ranking and mitigation of risks.

Proving the validity of the basic assumptions is a major part of design and construction. During the design it has to be realised that basic assumptions are not able to be 100% satisfied. There will always be a difference, no matter what measures are taken. The question is *when* irregularities result in a normative stage. This question has to be solved before constructing the lining.

Future designs might tend to more slender linings, especially when the conviction arises that the real structural behaviour is understood and can be predicted in a reliable and accurate way. Besides this, optimisation should take place by proven better operational protocols. Further optimisation can take place when the design of the TBM and the lining are highly tuned to each other.

From the perspective of risk-based design, one major risk can be announced: a normative assembling stage. Risk-based design starts with identifying the risks followed by ranking them in an attempt to determine what impact the risk has. When the assembling stage is normative, the design is not an economical optimum. A choice has to be made: either invest money to take measures to eliminate the assembling stage as the normative stage, or accept the cost of the assembly as the normative stage.

Acknowledgement

This article is based on the work published in the PhD thesis, *Design philosophy of segmented linings for tunnels in soft soils*,[1] which was funded by Holland Railconsult, The Ministry of Transports and Water Management and TNO Building and Construction Research, The Netherlands.

Reference

1 Blom C.B.M. *Design philosophy of segmented linings for tunnels in soft soils.* Ph.D. thesis, DUP, Delft, The Netherlands.

Elected *fib* officers (continued)

The March issue of *fib*-news reported on the results of the elections of the *fib* General Assembly in Osaka in October 2002 and introduced nine members of the Presidium by a brief curriculum vitae and a photo. This presentation is continued here for the members of the Steering Committee elected for 2002–2006.

Mikael W. Braestrup, Elected member, Steering Committee

Mikael W. Braestrup (b. 1945) obtained his PhD in Structural Engineering in 1970 from the Technical University of Denmark. After spending two years as a volunteer in charge of low-coast road construction in Peru, he was engaged in structural concrete research and teaching in Copenhagen, Denmark; and Cambridge, UK. In 1979 he joined the consulting company Ramboll, and worked for five years on the design and construction of offshore pipelines of the Danish natural gas transmission system. Subsequently he headed the company's departments of Marine Pipelines and Underwater Technology, and of Knowledge and Development. Since 1993 he has been attached to the Ramboll Department of Bridges. Recent assignments have included the preparation of the design basis (with the application of Eurocodes) of the 16 km Øresund Link between Denmark and Sweden. He has served on several Danish code committees, and been active in a number of international associations (CEB, FIP, IABSE and ACI), and is also currently a member of *fib* Commission 4: *Modelling*. Dr Braestrup is the author of a substantial number of papers and reports on concrete plasticity, marine pipelines, and bridge and tunnel projects. He has already been an elected member of the Steering Committee for 1998–2002, and, as Head of the Danish National Member Group, is also a member of the *fib* Council.

Eduardo C. Carvalho, Elected member, Steering Committee

Eduardo Cansado Carvalho (b. 1951) graduated in Civil Engineering from the Instituto Superior Técnico (Technical University of Lisbon) in 1974 and obtained a degree in Structural Dynamics from the Laboratório Nacional de Engenharia Civil – LNEC (National Laboratory for Civil Engineering), Lisbon in 1981 where he currently holds the positions of Head of the Centre for Earthquake Engineering Studies and Equipment, and Head of the Structural Analysis Division. His activities at LNEC also include applied dynamics, structural rehabilitation and design regulations, for both concrete and masonry. His work is reflected in more than 100 publications for which he is the author or co-author. Dr Carvalho is also active as a consultant and designer, mostly in the field of structural concrete. Having been a member of CEB Commissions and Task Groups for several years he was elected member of its Administrative Council from 1993–1998. He is also active in CIB, EAEE, and CEN where he became the Secretary of CEN/TC250/SC8 that deals with Eurocode 8. He has already been an elected member of the Steering Committee for the years 1998–2002; is presently active in Commission 7 on Seismic Design and several of its Task Groups; and also serves Portugal's National Member Group as one of its three *fib* delegates.

Brian D. Cox Elected member, Steering Committee

Brian D. Cox (b. 1942) graduated in Civil Engineering from the University of Cape Town, South Africa. He then worked as a design engineer for Maunsell and Partners in London on the design of prestressed concrete elevated motorways. Returning to South Africa he worked for Steeledale Systems and became involved in numerous prestressed concrete structures such as bridges, buildings, tanks, stadiums and tunnels. He currently holds the position of Managing Director at VSL Systems, South Africa. He is a member of the Concrete Society of Southern Africa, the South African Post-tensioning Association, the South African Institute of Civil Engineers and the Institution of Civil Engineers (UK). For several years he has been FIP Vice-President for South Africa and was an active member of the FIP Commission on Practical Construction. He has already been an elected member of the Steering Committee for 1998–2002, and, as Head of the South African National Member Group, is also a member of the *fib* Council.

Thomas J. d'Arcy, Elected member, Steering Committee

Thomas J. d'Arcy, President of The Consulting Engineers Group, San Antonio, Texas, graduated as a structural engineer from the University of Illinois and is a registered structural and professional engineer in 19 states. Being a fellow of the American Society of Civil Engineers (ASCE), and of PCI, he has served on and chaired various technical committees and is a member of its board of directors. His personal experience includes the design and construction of over 300 parking structures, and numerous stadiums, justice facilities, complex industrial buildings and segmental bridge structures. He has authored or co-authored substantial publications in these fields and lectured extensively at ACI, PCI and FIP conventions. His teaching experience includes a number of courses given in several universities. He is a past chairman of ACI's Technical Activities Council and immediate past chairman of the Parking Consultants Council of the National Parking Association. He received the Bernard Dutch Memorial Award of the National Parking Association and the Robert J. Lyman Award of the Precast/Prestressed Concrete Institute. He has also served as an elected member of the Steering Committee for 1998–2002.

Jean-Philippe Fuzier, Co-opted member, *fib* Presidium 2002–2004

Jean-Philippe Fuzier (b. 1941) graduated in 1965 from the École Centrale de Paris. He joined Gannett, Fleming, Corddry and Carpenter in Harrisburg (Pennsylvania, US) as a design engineer in 1967. Returning to France he later became involved in various prestressed concrete structures as a project engineer, then as Technical Director and later International Division Manager with Europe Études (Paris, France). Today, he holds the position of Scientific Director with Freyssinet International. In this position in the Freyssinet Group he has the worldwide technical responsibility for the application and use of Freyssinet services and products such as post-tensioning and stay cable systems. Author of numerous technical papers, Jean-Philippe Fuzier not only represents the Freyssinet Group in a number of international organisations, he is also a convener or member of several Task Groups in *fib*. He serves his country as head of the French delegation of *fib* and, after three years as Deputy Editor-in-chief, has taken over the responsibility of Editor-in-chief of *fib*'s journal Structural Concrete in 2001.

Steinar Helland, Elected member, Steering Committee

Steinar Helland (b. 1947) is an employee of Selmer Skanska A. S. Before 1982 he served as a site agent and area manager in Norway and Africa. Since then he has headed the company's Department for Concrete Technology. He has been active in standardisation and been a member of the Norwegian Committees' '*Code of design of concrete structures*', '*Concrete production and execution*', '*Cement*' and '*Silica fume*'. He is presently the Norwegian representative in the European Code Committee for *Concrete production* and *Concrete execution*. During the last 15 years, Steinar Helland has been active in research and research co-ordination at a national and European level. Fields of particular interest have been high-strength/high-performance concrete, durability and service life of concrete structures, curing technology and lightweight aggregate concrete. Since 1984 he has acted as a member of FIP Commission 1: *Concret*e, where he headed the working group on silica fume in concrete, and has been active in the joint FIP/CEB Working Group on high-strength concrete. Since 1988 he has been the Norwegian representative on the FIP Council. He has already been an elected member of the *fib* Steering Committee for 1998–2002, is presently also active in *fib* Commission 8 on Concrete and Commission 10 on Construction, and is a delegate of the Norwegian National Member Group.

Tao Xuekang, Elected member, Steering Committee

Xuekang Tao (b. 1939) graduated in Civil Engineering from Tsinghua University. Today a professor and consulting chief engineer at the Institute of Building Structures, China Academy of Building Research, Beijing, China, he commenced work with the Institute in 1964 as a research engineer. He later became a division director and was vice-chairman of the Institute from 1993–2000. From 1982–1984 he was engaged in structural concrete research at the University of Washington, Seattle, and in Cornell University, Ithaca, US. He is an active member of a number of Chinese code authorities relevant to concrete structures and the use of prestressed concrete. His recent research interests include prestressed concrete structures, design regulations for concrete, structural rehabilitation and FRP design and has written and co-written substantial publications in these fields. Being a member of a number of international associations (*fib*, ISO, ICCMC, ACI), Professor Tao has been a routine vice-chairman of directors at the Concrete and Prestressed Concrete Institute, China Civil Engineering Society, since 1996 and serves as China's National Member Group head of *fib* delegation.

Jun Yamazaki, Elected member, Steering Committee

Jun Yamazaki (b. 1942) has been a professor at the College of Science and Technology, Department of Civil Engineering, Nihon University, Tokyo, Japan, since 1990. He received his BSc and MSc from the University of Tokyo and his PhD from the University of Washington, Seattle, US, in 1975. He then worked for two years with the Concrete Technology Corporation in Tacoma, Washington and has been a faculty member of the University of Tokyo from 1977–1979, and of Tokyo Metropolitan University from 1979–1990. He has been one of the directors of the Japan Prestressed Concrete Engineering Association since 1990 and has served as editor of the Prestressed Concrete Journal (JPCEA) and of the English version of JSCE Standard Specification for Concrete Structures. In 1986 he was appointed as director of JCI and chairman of JCI Committee for Aesthetics of Concrete Structures. He is currently chairman of the JPCEA Committee on Hybrid Structures and secretary of the JSCE committee on Ecological Aspects of Concrete Civil Works. He had already been an elected member of the Steering Committee for 1998–2002, and serves Japan's National Member Group as one of its four *fib* delegates.

fib course, Athens —a great success

The course on *Strengthening with externally bonded FRP reinforcement: behaviour, design and applications*, held on 4–5 May 2003 immediately before the *fib*-symposium was a great success. Excellently prepared by Prof. Thanasis Triantafillou, the course was based on *fib* Bulletin 14, held

G. Balázs welcoming the participants

Thanasis Triantafillou handing out the certificates

by prominent members of Task Group 9.3 *FRP reinforcement for concrete structures,* and attracted 86 registered participants from 18 European, American and Asian countries.

The aim of this short course was to educate engineers in the field of strengthening/repair with externally bonded reinforcement consisting of fibre reinforced polymers. Undoubtedly the issue of upgrading existing civil engineering infrastructure has become of great importance during the last decade. Deterioration of bridge decks, beams, girders and columns, buildings, parking structures and others may be attributed to ageing; environmentally induced degradation; poor initial design and/or construction; lack of maintenance; and to accidental events such as earthquakes. The infrastructure's increasing decay is frequently combined with the need for upgrade so that structures can meet more stringent design requirements (e.g. change in use and/or function, increased traffic volumes in bridges exceeding the initial design loads), and hence the aspect of civil engineering infrastructure renewal has received considerable attention over the past few years throughout the world. At the same time, seismic retrofit has become at least equally important, especially in areas of high seismic risk.

Recent developments related to materials, methods and techniques for structural strengthening have been enormous. One of today's state-of-the-art techniques is the use of externally bonded fibre reinforced polymer (FRP) composites, which are currently viewed by structural engineers as 'new' and highly promising materials in the construction industry. The course covered the basics of FRPs as externally bonded reinforcement under the headlines

- material, systems, durability aspects
- general design aspects, safety concepts, structural behaviour
- flexural and shear strengthening, con finement
- detailing, practical execution, quality control
- design examples, case studies.

After a short address by President Jim Forbes, the convener of *fib*'s Special Activity Group Dissemination of Knowledge, György Balázs, welcomed the participants, expressing his satisfaction about the participation and the firm intention of the group to stimulate and organise more of these courses on topical issues from *fib*'s work in future*. On behalf of *fib* he thanked the organisers and lecturers who had taken the effort to come to the symposium two days early and making this course possible:

- Prof. Thanasis Triantafillou, University of Patras, Greece
- Dr Stijn Matthys, Ghent University, Belgium
- Mr Heinz Meier, Sika AG, Zurich, Switzerland
- Prof. Giorgio Monti, Universitá La Sapienza, Rome, Italy
- Prof. Stavroula Pantazopoulou, University of Thrace, Xanthi, Greece
- Dr Kypros Pilakoutas, University of Sheffield, UK
- Prof. Frieder Seible, University of California, San Diego, USA.

Handouts of their presentations and Bulletin 14 for each participant, along with further material offered by several sponsors, supported the course. After two days of work, stimulating discussions and a pleasant dinner, all participants received their certificates.

New bulletins

The series of *fib* Bulletins for the subscription year 2003 began with No. 21: *Environmental issues in prefabrication*, mailed to members in March 2003 who also received a copy of the *fib* Directory 2003. A brief description of the two bulletins follows. Non-members may order these or any other *fib* publication, (as well as those published by CEB and FIP before 1998), by simply following the instructions given on *fib*'s website http://fib.epfl.ch/publications/

Environmental issues in prefabrication: *fib* state-of-the-art report

fib Bulletin 21, Format 204 x 289mm, (approx DIN A4), 56 pages, ISBN 2-88394-061-4
Non-member price: 60 CHF, incl. surface mail

With the world's population growing at an exponential rate, much attention needs to be given to how the environment and resources are treated. The consequences for the building industry will be

- new laws having direct consequences for the choice of materials and building techniques
- sets of standards dealing with environmental matters
- customers preferring products that can document sound environmental 'behaviour'.

Based on this, it was in *fib* Commission 3: *Environmental Aspects of Design and Construction*, that a task group was created in order to draft a state-of-the-art report that would make an 'inventory' of all of the environmental issues in prefabrication, identify areas for improvement and collect available documentation expected to be required for prefabrication activities in the future.

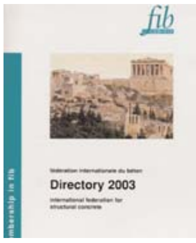
The task group's aims were to document existing environmental properties of precast structures, identify future possibilities, and collect data required for life cycle assessment of precast structures. In pursuit of these aims the following issues have been investigated: demountable structures; re-use of components; systems for the utilisation of the thermal mass of concrete; production; recirculation in the production process; transport; erection; supplementary materials; and the environment in the plants.

During the process of preparing the document it became evident that the environmental issue does not have the worldwide attention that was expected. Although much is written about environmental matters all over the world, much of it is philosophical consideration backed up by very few facts. Many countries in Europe as well as Japan have undertaken excellent scientific work, but it seems that implementation on a practical level varies considerably. It therefore became difficult to collect data from all over the world, and as a result the examples presented are dominated by results from the Nordic countries, which—together with the Netherlands—seem to be the most advanced on a practical level.

It also became evident that there are large differences in the systems used for data collection. Tables etc. containing 'facts' are not always comparable as the assumptions made during the research may have been different. Wherever possible this has been pointed out in the text.

List of contents:
- Introduction
- Scope
- Production
- Transport and erection
- The structure
- References
- Annexes dealing with:
  -Life cycle analysis
  -Environmental product declarations
  -How to utilise the thermal mass
  -Example of comparison of structural systems.

Directory 2003



fib directory 2003, Format 209 x 290mm, (approx DIN A4), 108 pages.
Non-member price: 60 CHF, incl.surface mail

A General Assembly took place in Osaka in autumn 2002 resulting in changes in the Presidium membership; also, the biannual meetings of Steering Committee and Council modified details of *fib*'s structure—all commissions went into a second four-year cycle, often under renewed chairmanship or with at least partially new members. It became necessary therefore, to publish the present state again in a printed form. The Working Programmes of Commissions and Task Groups, Working Parties and Special Activity Groups reflect the state as known to the secretariat at this time.

As in the previous issue, complete addresses are given at the end on the 'yellow pages'. No distinction is made there between *fib* members and participants in one of the working bodies; as membership of *fib* is not a pre-condition to participate in its work, the terms 'member of *fib*' and 'member of a commission or task group' are not synonymous. Members of a commission will normally become *fib* members—at least if they wish to go on for a second four-year term. Many members of task groups, however, begin by being attracted by the work itself. Quite often, they will then enjoy the friendly atmosphere and international co-operation so much that they decide to join the ranks of *fib* members, either personally or through their employer!

Finally it should be mentioned that virtually all information made available in the printed directories (published every second year) is permanently updated and available on *fib*'s website (http://fib.epfl.ch). Access to certain information, however, (e.g. working programmes or addresses) is reserved for members only.

Single Bulletins may be ordered by anyone via the internet (http://fib.epfl.ch), mail, e-mail or fax. They are sent to all individual subscribers and all corporate members of *fib* regularly as part of their annual subscription. Ordinary members only receive the journal. They are entitled, however, to order a Bulletin once a year at a discount rate.

Obituary

Troels Brøndum-Nielsen 1917–2003

Honorary member of CEB, and fellow of the ACI, Troels Brøndum-Nielsen died on 5 March 2003 at 85 years of age. Brøndum, as he was called by his Danish friends and colleagues, held the chair of concrete structures at the Technical University of Denmark for 24 years. His university engagement was preceded by 22 years of practice, including 13 years as chief engineer with the internationally renowned Danish Contractor Christiani & Nielsen A.S. In 1962 he obtained the Dr.Techn. degree for his thesis *Axisymmetric Bending of Shells*, which demonstrated his highly logical thinking by developing very simple but exact design solutions to this complex problem.

Brøndum was fascinated by the neatness of mathematical formulae representing complex combinations of load and structural form, as documented through numerous articles in international magazines treating combined creep, shrinkage and relaxation in eccentrically loaded reinforced and prestressed concrete sections.

Brøndum was an active and treasured colleague in both CEB and FIP. In both of these organisations he was the national Danish representative for nearly a generation. The new methods of structural calculations, tested and disseminated within these professional organisations, were carefully evaluated by Brøndum, further perfected in his series of blue textbooks, and then adopted into his lectures and specialist courses. In addition, he strongly supported the limit state design methodology introduced in the Danish Code of Practice in 1973.

Several generations of Danish structural engineers have been privileged by Brøndum's early introduction of the most advanced theories for the design of concrete structures. His deep engagement in CEB together with vice-presidency of FIP also led to his early engagement in partially prestressed concrete, thus contributing to the establishment of the continuous link from non-prestressed to fully prestressed structures. Participants in the 1973 CEB *Advanced Course on Structural Concrete* in Portugal, organised by Brøndum's personal friend and former President of CEB, the late Professor Julio Ferry Borges, will recall Brøndum's good humor and inspired lecturing based on his textbook '*Structural Concrete*' written for the occasion.

Throughout the last ten to fifteen years of his participation in the governing bodies of both CEB and FIP Brøndum-Nielsen actively supported the merger of these two international organisations, an effort which finally succeeded just five years ago with the successful creation of *fib*.

Steen Rostam

Short notes

The Slovak National Delegation in *fib* communicates that their **National Report of the Slovak Republic** on reinforced and prestressed concrete construction, as delivered during the *fib* Congress in Osaka, is still available. Contact: Vydavatelstvo Inzinierske stavby s. r. o., Vysokoskolska 4, 04200 Kosice, Slovakia. Tel/fax: +421 55 602 4247; email is.casopis@tuke.sk; website www.casopis.is.szm.sk.

A two-day international symposium on **Actual Developments in Bridge Design and Construction** is being held at the Technical University of Darmstadt, Germany, on 1–2 October 2003. Five out of 20 contributions from invited speakers are given in English, the rest in German. Website: http://www.c-a-graubner.de

ASBI, the American Segmental Bridge Institute, in cooperation with Concrete Products magazine, calls for entries to the 2003 Competition **Bridge Award of Excellence** to be made before 1 August 2003. Contact: ASBI, 9201 North 25th Ave., Suite 150 B, Phoenix, AZ 85021 USA. Tel: +1 602 997 9964; fax +1 602 997 9965; email asbi@earthlink.net; website: www.asbi-assoc.org.

The date for the conference **48th Ulmer Beton- und Fertigteil-Tage 2004** has been fixed for 17–19 February 2004.

fib membership benefits

fib has 39 National Member Groups as statutory members, and about 900 individual or corporate members in about 60 countries. The objectives of *fib* are to develop at an international level the study of scientific and practical matters capable of advancing the technical, economic, aesthetic and environmental performance of concrete construction. These objectives shall be achieved by the stimulation of research, the synthesis of findings from research and practice, and the dissemination of the results by way of publications, guidance documents and the organisation of international congresses and symposia. The production of recommendations for the design and construction of concrete structures, and the information of members on the latest developments also belong to these objectives.

Individual membership is offered in two categories with the following benefits: *Ordinary members* receive the quarterly journal *Structural Concrete* and once a year a technical publication of their choice ('Bulletin') at a discount rate. *Subscribing members* receive a copy of all technical publications (on an average six Bulletins/year and the journal) and may order any quantity of publications at a discount rate (including former CEB or FIP publications).

Corporate membership is available in three categories with the following benefits: *Associate members* (libraries, companies, engineering offices etc.) may nominate one representative to be registered as individual member of *fib*, and, in addition to the benefits described above for subscribing members, may request two copies of all technical publications to be sent without extra charge. In addition to this, *supporting members* are entitled to nominate two representatives to be registered as individual members. They are also entitled to a special mention in the directory and receive discount rates when advertising in the journal *Structural Concrete*. In addition to this, *sponsoring members* will enjoy a special mention on the *fib* website, including a link to their own homepage. They may use *fib*'s logo by stating 'Sponsoring member of the fib' in their letterhead, and may nominate three representatives to be registered as individual members. They are entitled to nominate a member of a task group in one particular field or interest and may send a representative to the General Assembly.

In addition, all members in all categories receive free of charge the latest Directory and enjoy special access to certain information presented on *fib*'s website. Having attended official *fib* congresses or symposia, they will also enjoy reduced subscription fees for the year after.

Application Form

I/my company want(s) to join the fib as a:

- ❑ Ordinary Member (130 (40) CHF/year)
- ❑ Subscribing Member (400 CHF/year)
- ❑ Associate Member (750 CHF/year)
- ❑ Supporting Member (1250 CHF/year)
- ❑ Sponsoring Member (2500 CHF/year)

Last name .... First name or initials .... Title .... Date of birth ....

Company ....

Address ....

Phone .... Fax .... Email ....

I/we will pay by ❑ Eurocard/Mastercard ❑ Visa card No. .... Expiry date ....

❑ remittance to the *fib*'s account No. 710.250.00 V, fédération international du béton, 1015 Lausanne, at the Union Bank of Switzerland, Case Postale 2950, CH-1211 Geneva 2, Dépôt (Swiftcode UBSWCHZH12A, IBAN CH19 0024 0240 7102 5000 V)

❑ sending to the *fib* secretariat a cheque made out in CHF, drawn on a Swiss clearing bank

Signature .... Date ....

***fib*, Case Postale 88, CH-1015 LAUSANNE, Switzerland, Fax.: (+41.21) 693 5884, Email: fib@epfl.ch, Web: http://fib.epfl.ch**

Congress and symposia

The calender lists *fib* congresses and symposia (also co-sponsored events and, if space permits, events supported by the *fib* or organized by one of its National Groups). It reflects the state of information available to the Secretariat at the time of printing and the information given may be subject to change.

Date and location	Event	Main organizer	Contact
17–19 July 2003 Brisbane, Australia	21st Biennial Conference Concrete in the 3rd Millennium	CIA	CIA—Concrete Institute of Australia PO Box 848 Crows Nest NSM 1585, Australia Tel.: +61 2 9903 7770; Fax: +61 2 9437 9703 Email: exec@coninst.com.au Web: http://www.coninst.com.au
21–22 July 2003 Newark, NJ, USA	Design and Construction of Segmental Concrete Bridges	ASBI	ASBI—American Segmental Bridge Institute 9201 N. 25th Ave., Ste. 150 B Phoenix, Arizona 85021-2721, USA Tel.: +1 602 997 9964 Fax: +1 602 997 9965 Email: asbi@earthlink.net Web: http://www.asbi-assoc.org
17–20 August 2003 Reykjavik, Iceland	3rd International Symposium on Self-Compacting Concrete	IBRI RILEM	IBRI—SCC 2003 112 Keldnaholt, Iceland Tel.: +354 570 7300 Fax: +354 570 7311 Email: nielsson@rabygg.is Web: http://www.ibri.is/scc/
19–22 October 2003, Orlando Florida, US	PCI Annual Convention in conjunction with the 3rd PCI/FHWA International Symposium on High Performace Concrete	PCI	PCI—Precast/Prestressed Concrete Institute, 209 W Jackson Boulevard, Suite 500, Chicago, IL 60606, USA Tel.: +1 312 786 0300; Fax: +1 312 786 0353 Email: info@pci.org Web: http://www.pci.org
3-4 November 2003, Dallas, Texas, US	ASBI Convention	ASBI	ASBI—American Segmental Bridge Institute 9201 N. 25th Ave., Ste. 150 B Phoenix, Arizona 85021-2721, USA Tel.: +1 602 997 9964 Fax: +1 602 997 9965 Email: asbi@earthlink.net Web: http://www.asbi-assoc.org
26–28 April 2004 Avignon, France	***fib* Symposium: Concrete Structures: The Challenge of Creativity**	**AFGC (*fib* group France)**	**Secretariat Scientific Committee: Mme Nathalie Chartier, c/o Freyssinet, 1 bis, rue du Petit Clamart, F-78140, VELIZY, France Tel.: +33 1 4601 8530; Fax +33 1 4601 8681; Email: nchartier@freyssinet.com; Web: http://www.fib-avignon2004.org**

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