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TEACH IN
STRUCTURAL CONCRETE

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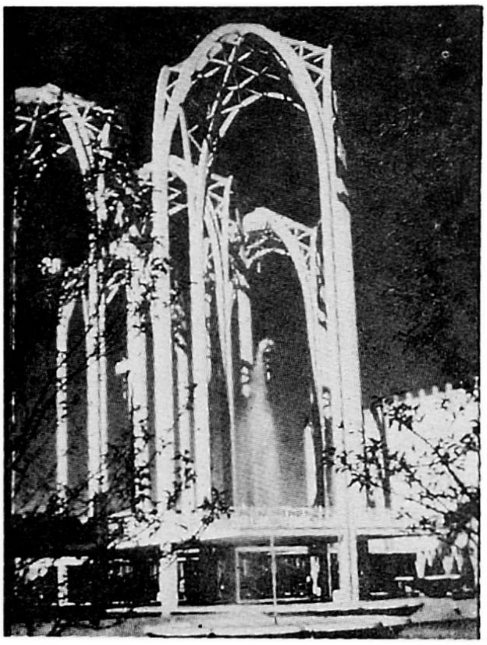
March 2, 1992
New Delhi

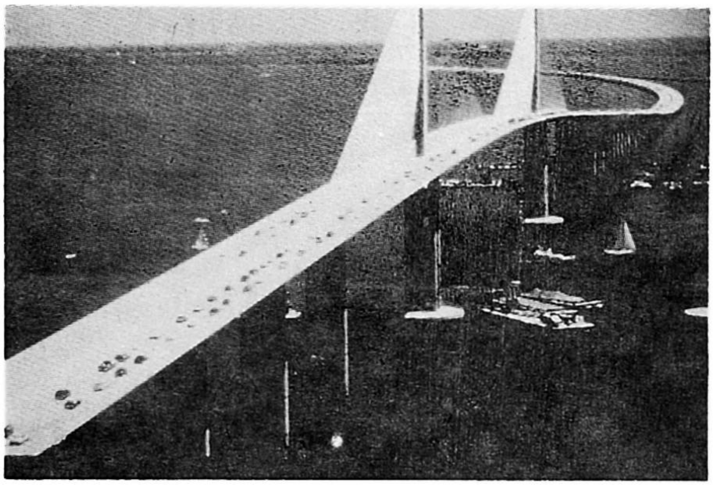
In this Introductory section of today's Teach-In on Structural Concrete, we wanted to explain why IABSE, and particularly Working Commission III, Concrete Structures, is leading an international effort to refocus our approach to design of concrete structures.

Indeed -- Why Structural Concrete?

After all, Reinforced Concrete is well over 100 years old and Prestressed Concrete is now over 50 years old.

We have shown that we can build truly beautiful structures





and breathtaking bridges -- monuments that any age would envy.

In view of this well-developed industry and the impressive knowledge base which surrounds it --

- Why do we want to re-examine fundamental approaches?
- Why is there any urgency to do it now?

Structural concrete is definitely a world-wide industry. Projects frequently cross continental lines producing an increased need for harmonization. Today's communication explosion creates global interaction. Engineers in one country frequently work on projects a continent away with totally different codes and standards.

The lack of harmonization is particularly apparent when the project includes prestressed concrete. While CEB and FIP have collaborated in an impressive way, the world-wide status is still disturbing.

There is an absence of an overall unifying approach which smoothly meshes reinforced and prestressed concrete. The fragmentation is obvious in technical societies in countries such as the USA where we even have one professional group for pretensioners and a completely different one for post-tensioners. It is mirrored by serious divisions in education and textbooks for reinforced concrete and for prestressed concrete.

The complaints of many designers working in many lands led Working Commission III to become conscious of the growing frustration of code users with our man-made fragmentation. We decided that the time to unify Structural Concrete is <u>now</u>. We had a most successful colloquium in Stuttgart in April 1991 where it became apparent that the feeling was world-wide. We hope that the results and the summary statement from the Stuttgart Colloquium will spark other organizations to act.

During this Teach-In we want all of you to focus on the advantages of a consistent approach to reinforced and prestressed concrete in both education and practice. In the talks that follow we will be focusing on a design approach that gives major focus to overall structural behavior and flow of forces throughout the structure. It will reacquaint you with useful and highly transparent models.

We want to, wherever possible, eliminate conflicts in codes and standards.

Concrete does not stand alone -- in each country structural engineers must develop an overall framework to facilitate mixed or composite construction.

In order to communicate our ideas, we suggest a few definitions.

The most basic is the term "Structural Concrete." We ask that this term be used for the entire spectrum of concrete used for structural proposes from non-reinforced applications through applications which have a mix of non-prestressed and prestressed reinforcement.

Another useful term is "active reinforcement" or some may prefer the term "prestressed reinforcement". Note we consider only that portion of the reinforcement capacity developed by the construction operations as "active."

The complementary term is "passive reinforcement" or some may prefer the term "non-prestressed reinforcement." Note that this includes that portion of the active reinforcement capacity which is not developed during prestressing operations. This is the stress increase above the effective prestress level developed in bonded tendons as they resist higher levels of applied load.

It is very convenient to think of prestressing as a load type action applied by the constructor which are additive to other loads. These loads, including their axial and normal components and eccentricities, can be entered into the analysis and combined with other loads. The final effect must be countered by the resistance.

ACTIVE REINFORCEMENT

- Any reinforcement which is mechanically electrically, or chemically stressed by constructor controlled methods during the construction process
- Only that portion of the active reinforcement capacity which is developed by the construction operations

PASSIVE REINFORCEMENT

- Any reinforcement which is not actively stressed by constructor controlled methods in the construction process
- Includes the developable capacity of active reinforcement in excess of that developed during the construction process

SUPERFLUOUS TERMINOLOGY

- Fully prestressed concrete
- Partially prestressed concrete
- Reinforced concrete
- Secondary moments or Parisitic moments

USEFUL TECHNICAL TERMINOLOGY

- Pre-tensioning
- Post-tensioning
- Internal tendons
- External tendons
- Bonded reinforcement
- Unbonded reinforcement
- Precast concrete
- Cast-in-situ concrete

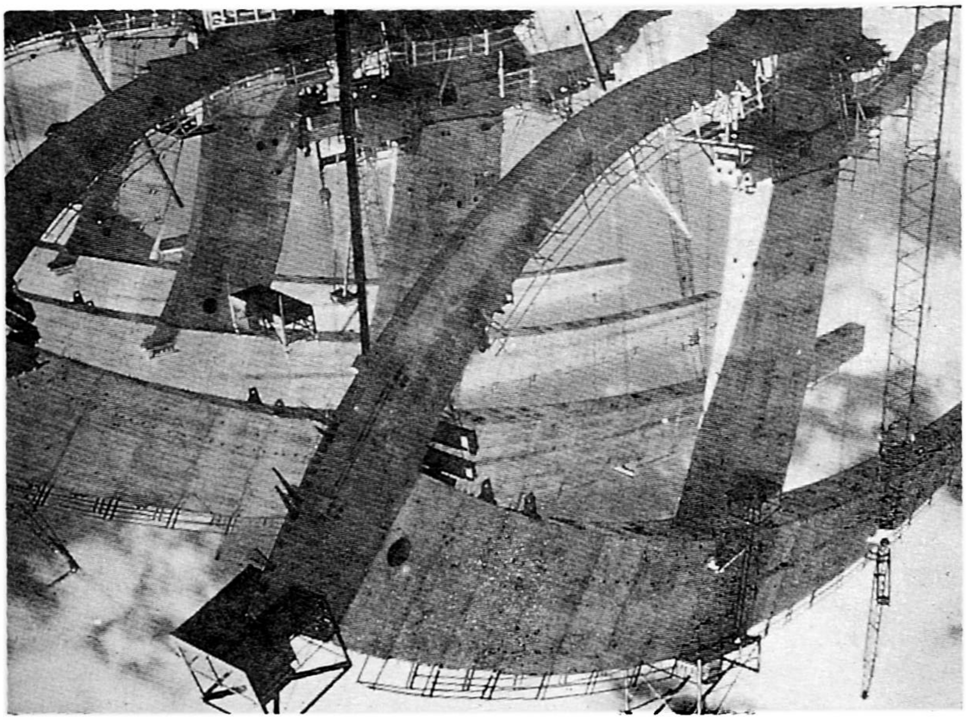
By the use of these definitions it becomes unnecessary to use some terms which cause considerable confusion such as fully prestressed concrete and partially prestressed concrete. Prestressed concrete members all have both active and passive reinforcement. Thus, prestressed concrete members are also reinforced concrete although we usually use that term to imply non-prestressed concrete. Using "Structural Concrete" eliminates these artificial distinctions.

One of the main advantages in considering prestressing as a load is that calculations of secondary moments becomes de-mystified and their redistribution more obvious. All that is required is a conventional analysis which correctly considers boundary conditions, restraints, and realistic stiffnesses.

Many traditional technical terms continue to be useful but do not require separate codes, standards or design procedures.

It is amazing that constructors have little difficulty in treating all of the various forms of structural concrete in a unified way while we designers often run into artificial discontinuities in theories, approaches, codes and standards.

Both designers and constructors conquer these man-imposed obstacles in their battles with the forces of gravity and nature. Why do we make life so hard for ourselves in the design process?



So that you may better understand WCIII concerns, we have outlined a few inconsistencies drawn heavily from a North American perspective, but found to be fairly representative.

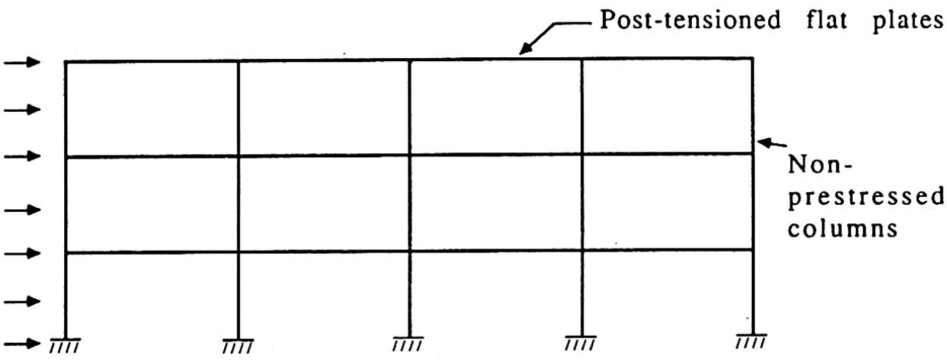
In spite of the rapidly growing use of prestressed concrete construction in the USA, most American universities either do no teach a course on reinforced concrete or restrict such courses to graduate students.

Our separate treatment of "reinforced concrete" and "prestressed concrete" in university courses and in textbooks gives the newcomer the false impression
that these are fundamental differences between the subjects.

It is not only the universities that are divided -- Many countries have separate standards for "reinforced concrete" and "prestressed concrete." Often these separate standards have conflicting notation. Totally different approaches are used to express the same fundamental principles -- Approaches lack transparency and abound in confusing empirical equations. The variety of overlapping codes and standards is breeding errors rather than minimizing them.

When a country has completely separate standards for reinforced concrete and for prestressed concrete, it becomes very difficult to decide questions such as the proper degree of restraint which these prestressed slabs provide for the non-prestressed columns. Modern designers live in a mixed world!

CODES AND STANDARDS

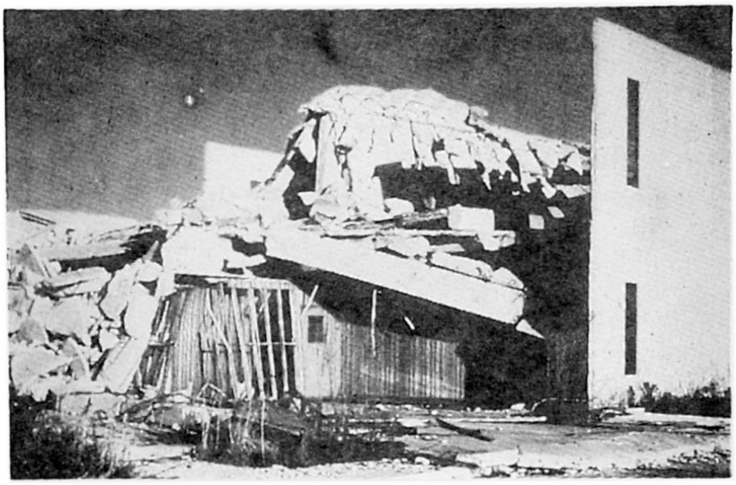


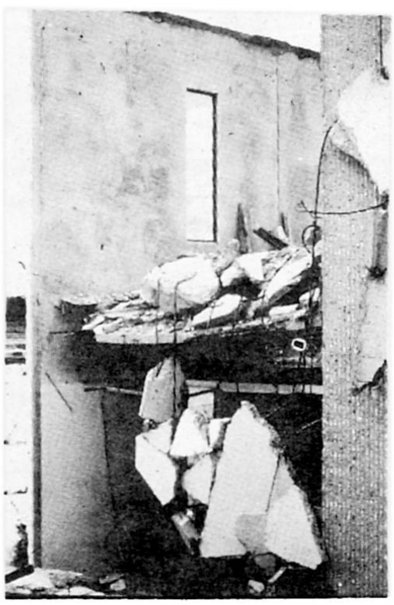
A universal complain is that codes and standards are becoming increasingly complex as they blindly adopt excellent "research models" instead of transparent, designer-friendly models which we will emphasize today. Innovation is limited by the narrowness of the empirical models.

Numerous structures have experienced substantial distress and structural failure due to poor detailing induced by the lack of overall consideration of the flow of forces and the restraints active in the structure.

An ugly example is this office building for a major engineering company. Structural engineers employed by the company frequently visited the construction site to see their new offices growing.

The building was virtually complete - the electricians incorrectly wired a 3-phase electric motor. They turned on the power - a small motor on the roof surged - the entire building collapsed with a number of workmen killed.

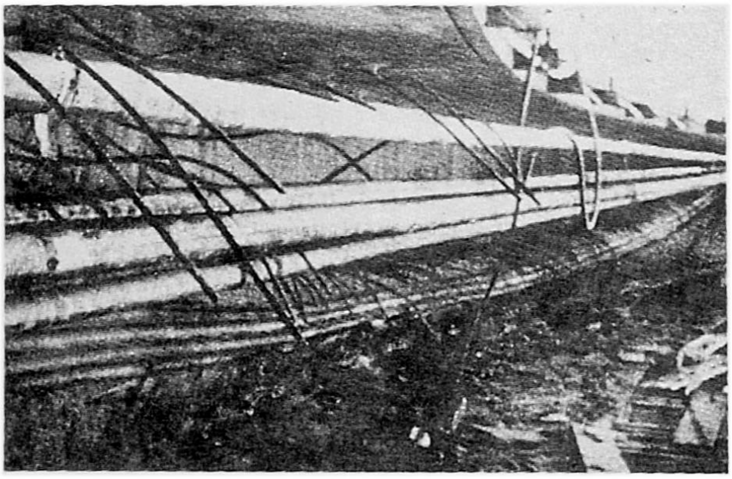




The tilt-up prestressed walls and the cast-in-situ post-tensioned beams were correctly proportioned in terms of section-by-section analyses. No thought or attention was given to tieing the various members together. The beams had no supports under their ends and were rubbing by friction on the walls -- when friction was broken, the building collapsed.

Minimal attention to force paths would have saved lives and property.

Another example of poor detailing due to lack of consideration of applied loads and force paths was shown in a major curved bridge.



No tie-back reinforcement and inadequate cover was present to equilibrate out-of-plane forces when the tendons were stressed -- the arc became a chord. Again, minimal attention to good detailing and force paths would have prevented their collapse

The primary tools required to implement a consistent structural concrete methodology need to be highly transparent and design-oriented such as the Strut-and-Tie Models. Tools like interactive graphic programs and finite element analysis can be useful if they are used to help with force paths and not as strictly numerical output.

In this session today we hope that we can bring to this great Indian sub-continent our version of what a consistent and transparent design philosophy can do.

Our challenge today is to help you move towards unity, simplicity and clarity in your approach to Structural Concrete.

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