Application of High Performance Concrete in Bridge Design

Q4: *What design considerations should a bridge engineer plan for when designing with high performance concrete?*

A4: High performance concrete (HPC) is currently a very hot topic in the engineering community and especially among bridge engineers. Several symposia and conferences on HPC have already been carried out in the United States and the world. The May-June 1993 PCI JOURNAL was devoted exclusively to this subject. At this year's PCI Convention in New Orleans, Louisiana, a joint PCI/FHWA International Symposium on High Performance Concrete will be held, October 20-22, 1997.

At the outset, HPC can be defined as concrete that not only has high strength [usually (but not always) over 10,000 psi (69 MPa)] but also has long-term durability.

Bridges with HPC have been encouraged by the Federal Highway Administration. With improved durability and strength parameters, HPC becomes a favorable material for highway construction. The application of HPC brings initial and long-term economic benefits. Designers are allowed to design bridges with longer spans and wider spacings. HPC bridges are expected to have longer lives and less maintenance expenses because of the improved durability of HPC.

The question asked is what should be considered by the structural engineer when HPC bridges are designed. Research results show that material properties of HPC such as modulus of elasticity, creep, and shrinkage are different from those of conventional concrete. The good news is that one can use his/her favorite computer program with no internal modification to the program. Indeed, most of the benefits of HPC in precast, prestressed concrete girders can be realized by just using the proper values of compressive strength at release, f'_{ci}, and at service, f'_c.

Further design refinements could result in a possible savings of a couple of strands. These refinements would include modification of the modulus of elasticity, primarily to get better estimates of camber and deflection. Also when one uses improved creep and shrinkage predictions, prestress losses would be slightly reduced and long-term deformations would be better predicted.

In the past, there has been some discussion about the fact that the concrete modulus of rupture increases from $7.5\sqrt{f'_c}$ for conventional concrete to $12\sqrt{f'_c}$ for HPC. However, as Fig. 4 shows, this adjustment does not result in significant improvement in span capacity. It is the higher compressive strength, and the corresponding ability of a member to accept more prestressing that has the most impact on improving span capacities.

For example, Curves 2 and 3 in Fig. 4 show that for a Nebraska NU1100 I-girder bridge for 12,000 psi (83 MPa) concrete, 58 strands can be used as compared to only 36 strands for 6000 psi (41 MPa) concrete (Curve 1).

References

1. High Strength Prestressed Concrete, Special Issue, PCI JOURNAL, V. 38, No. 3, May-June 1993, 140 pp.
2. Proceedings of SHRP High Performance Concrete Bridge Showcase, Houston, Texas, March 25-27, 1996.
3. Proceedings of SHRP High Performance Concrete Bridge Showcase, Omaha, Nebraska, November 18-20, 1996.

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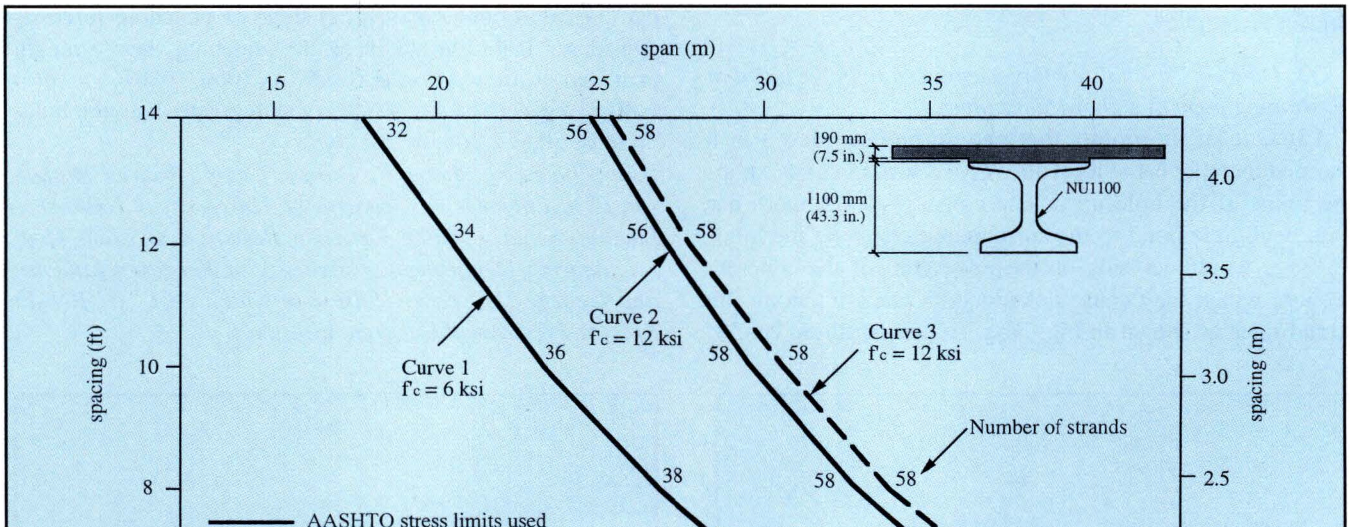

Fig. 4. Impact of using HPC on simple span capacity of NU1100 I-girder bridge.