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ULTRA HIGH-PERFORMANCE CONCRETE BEHAVIORAL STUDY

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Abstract

It is investigated in the study paper how UHPC reacts when used as a bridge girder material. The early-age shrinkage, transfer length, creep behavior, and shrinkage following steam treatment of four optimized girders were all investigated. Data was gathered using vibrating wire gauges at strategic locations inside each girder after re casting. Even though the recorded shrinkage and creep are incredibly low, as is typical for UHPC, many other variables have been studied, including how closely temperature and work restraint affect shrinkage, and the geometry and strand pattern of the girder affect prestress transmission. The results suggest that UHPC might act as a bridge.

Keywords: UHPC, bridge girders, shrinkage, creep, vibrating wire gauges

INTRODUCTION: It is widely acknowledged that transportation infrastructure is essential to the country's economic health and effectiveness. Distributing products to the right markets swiftly and affordably is a vital requirement for manufacturers; this allows people to go to work and conduct business. Recent disasters like the flooding along the Mississippi and Missouri rivers and the Northbridge earthquake in California serve as examples of how much any significant disturbance in the flow of people or products affects a wide range of enterprises and sizable population groupings. [6] To investigate the relationship between funding for highways and bridges and the country's capacity to maintain economic performance and growth, the FHWA developed a priority research project in 1989. Significant public expenditures are still warranted because of the connection between transportation and economic development. The advantages of our highway system cut across all social strata and may be shown in several ways. According to industry research, our extensive highway system is necessary to develop new management forms and reduce social costs. For instance, a more affordable, effective, and dependable highway network enables businesses that provide transportation to restructure their manufacturing processes and access new markets, resulting in a more excellent selection of more excellent and serve lowe cheaper prices. Reduced logistical expenses will continue to provide consumers and manufacturers with exceptional advantages. [6] Ultra-High Performance Concrete (UHPC) is now being evaluated [11] by the Federal Highway Administration (FHWA) at its Turner-Fairbank Highway Research Center (TFHRC) for usage in the transportation sector

[4]. Due to its impressive mechanical qualities, it uses less material than typical reinforced concrete bridges.

EXPERIMENTAL INVESTIGATION:

The girder has an eight-foot broad deck and is 70 feet long and 33 inches deep. There is no mild steel in the cross-section, only 22 to 24 pre-stressing strands. Four of these girders were built using 28 ksi UHPC, which has a compressive strength. [12] Two of these girders were intended to be used in the bridge construction at the Turner-Fairbank Highway Research Center. These girders will be frequently examined and observed over several years to ascertain the UHPC bridge's long-term shrinkage and creep behavior as wander characteristics, including long-term deflections and durability. Verify the behavior and capacity of this material/girder combination; the remaining two girders will be put through destructive testing. The girder’s short-term behaviors were also observed as instantaneous shrinkage, shrinkage during steam treatment, prestress transfer, short-term creep, camber, and other mid-span behaviors.

MATERIAL PROPERTIES:

UHPC, in general, is a steel fiber-reinforced reactive powder concrete that, on average, has a compressive strength that is twice as high as any High-Performance Concrete (HPC)[9] used in the construction of American bridges. The reactive powder concrete was first created by the French company Bouygues SA. It is designed to be a highly compacted concrete with a small, unconnected pore structure that helps to reduce many of the limitations of conventional HPCs. These improvements are made possible by using finely ground powders in combination with the omission of coarse aggregates. Most materials’ tensile strength and toughness are due to the incorporation of tiny steel fibers. These fibers prevent the girders from requiring mild reinforcing steel and stitch the fabric back together once it has cracked. Procedures comparable to those already established for various HPCs can be used to insert and cure UHPC. The fluid mix doesn't need any internal vibration and practically places itself. If necessary, external form vibration causes the mixture to fit into position quickly.

Quickly determine the compressive strength of UHPC, tests were conducted on cylinders of three in. diameter and six in. length. Testing was carried out by ASTM C39, except for changing the load rate to 150 psi/sec to ensure that the failure load was reached promptly.

The 28-day strength results for various curing regimes are given below in Table 2

Material	**Amount (lb/yd3)**	**The percent by Weight (%)**
Portland Cement	1200	28.5
Fine Sand	1720	40.8

Silica Fume	390	9.3
Ground Quartz	355	8.4
Accelerator	50.5	1.2
Steel Fibers	263	1.2
Superplasticizer	51.8	6.2
Water	184	4.4

Table 1 UHPC Composition

TESTS TO BE INVOLVED:

Compressive Strength:

The compressive strength of UHPC was measured using cylinders with a three in. diameter and six. Length [3]. Testing was carried out by ASTM C39, except for changing the load rate to 150 psi/sec to ensure that the failure load was reached promptly. Table 2 below lists the 28-day strength findings for various curing procedures.

Curing Method	**Compressive Strength (KSI)**
Steam	28.0
Ambient Air	18.0
Tempered Steam	25.2
Delayed Steam	24.9

Table 2 Compressive Strength of 3 x 6 in. UHPC cylinders

Tensile Strength:

Both before and after breaking, it was shown that UHPC had a substantially higher tensile strength. It provides several benefits, including stiffer post-cracking portions and a more extraordinary pre-cracking tensile load-carrying ability. [2] Several experiments were carried out to determine the tensile strength of UHPC, including split cylinder, straight cylinder, and mortar briquette tension tests. Some of the direct tensile breaking strength results for various regimes are shown in Table 2.3.

Curing Method	**Cracking Strength (KSI)**
Steam	1.60
Ambient Air	0.82
Tempered Steam	1.14
Delayed Steam	1.62

Table 3 Direct Tensile Cracking Strength of UHPC

Shrinkage:

UHPC bars measuring one in. by one in. and 11 in. long were cast and cured for a limited shrinkage evaluation based on ASTM C157. [1] The first measurement was recorded right after the molds were stripped, and the last reading was taken when the curing process was finished or at 28 days for specimens cured in ambient air. The results of the shrinkage tests are displayed in Table 4.

Curing Method	**Shrinkage (%)**
Steam	0.047
Ambient Air	0.062
Tempered Steam	0.025
Delayed Steam	0.050

Table 4 shrinkage test

Experimental Work: The experimental program and instrumentation setup for the UHPC girders [13]. First, it describes the details of the optimized cross-section and prestressing scheme for each beam, followed by a description of the strain-sensitive equipment and measuring instruments used for capturing the behavior of the girders.

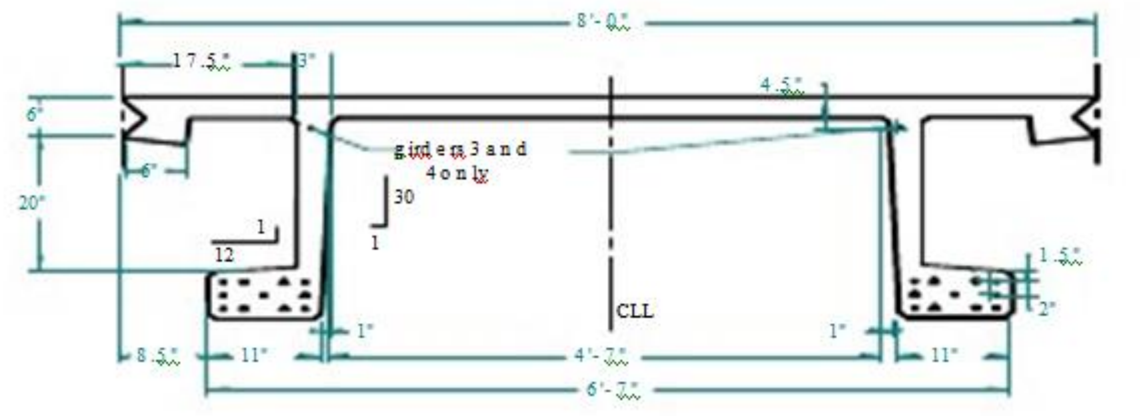

Fig 1: Section details for girders 1,2,3 and 4

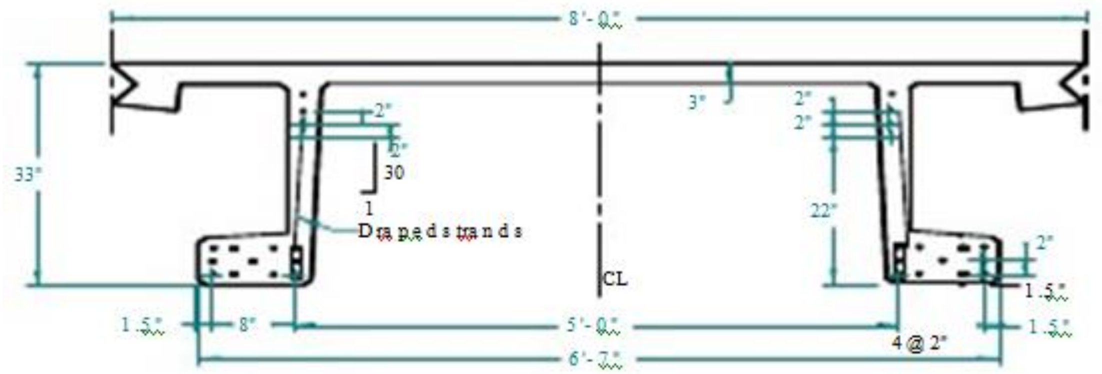

Fig 2:Girder section details

Girder 1: Thirteen vibration wire gages were cast into Girder 1. Nine were placed in the transfer region at the east end of the south bulb. From earlier estimates (Steinberg E., Lubbers A., ISHPC 2003), it was approximated that the transfer length should be in the range of 10 in. to 12 in. The three strands at the outer edge of the bulb are all fully bonded. Hence, as seen in Figure 2. [7]The gages are installed in the concrete between the bottom two outer strands. The gages 1SA12I, 1SA16I, 1SA20I, 1SA24I, and 1SA30I are located between strands that are de-bonded to 12 in. from the end of the girder. Ideally, the strain in the concrete near these gages should be a function of the pressure due to the fully bonded strands and the stress due to the strands de-connected to 12 in. and transferred after that. [8]These gages aim to study the transfer behavior of the second set of strands, which are de-bonded to 12 in. The spacing between the gages has been increased, and an extra gage (1SA12I) has been placed at 12 in. (effectively 0 in. of transfer) to record the strains in the concrete near the second set due to the transfer of the fully bonded strands.

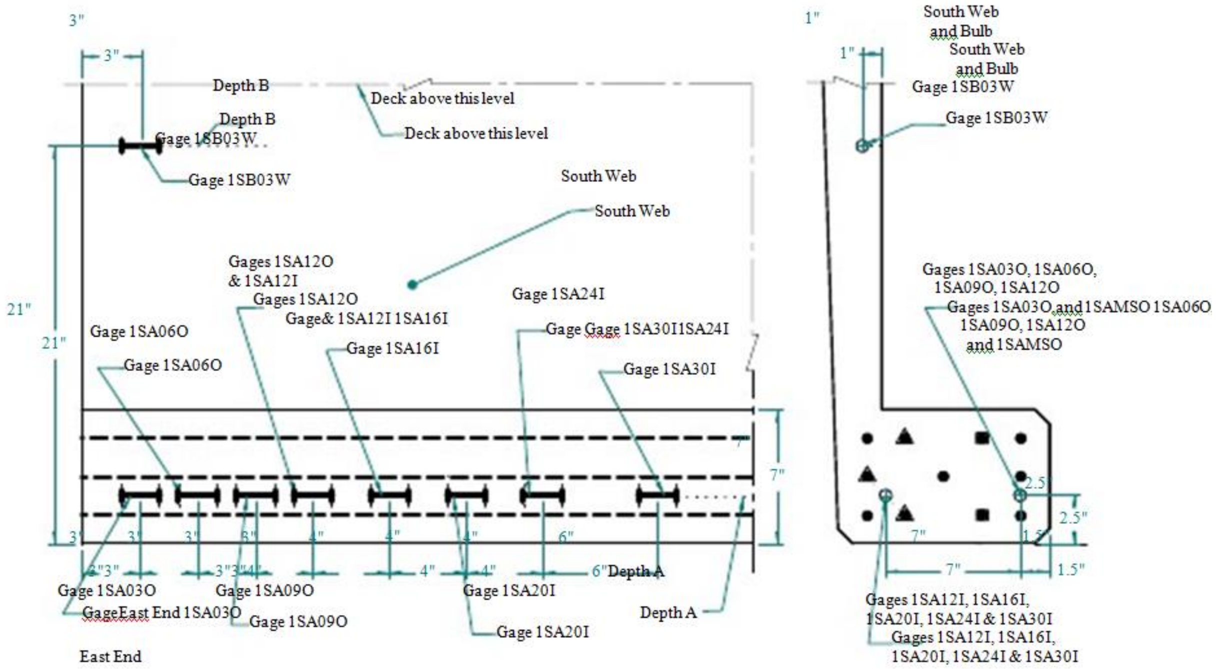

Fig 3: Instrumentation plan for vibrating wire gauges

Girder 2: The instrumentation in the second girder was similar to that in the first, except for a few minor changes. The gages at 24 in. and 30 in. in the inner part of the bulb were not installed. As shown in figure 3. gages 2NB03W, 2NAMSO, 2MCMSD, and 2MCMSL were kept at the exact relative location, except that they were moved to the north bulb. White more points were installed along the north side of this girder according to the same plan followed for girder 1. Figure 4 (a) shows the White points for the underside of the overhang, while figure 4 (b) shows the vibrating wire strain gages tied between the strands in the bulb.

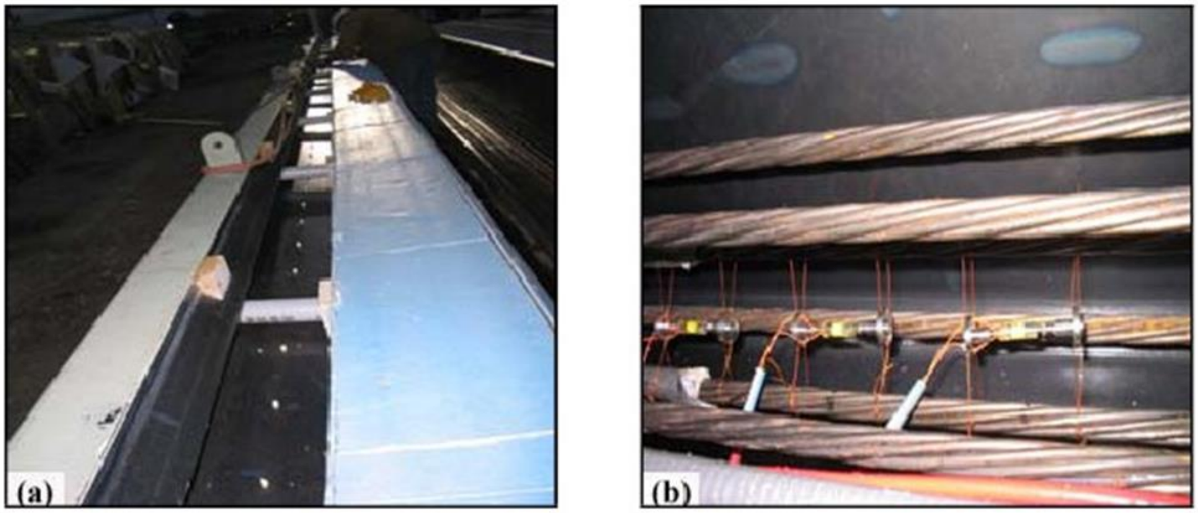

Fig 4(a): White more points and (b) Vibrating Wire Strain Gages.

Girder framework: The formwork for the cross-section of this girder exhibits considerable restraint on the beam as the concrete begins to set and shrink. But the early-age shrinkage behavior of UHPC[11] is such that it causes the UHPC matrix to crack if it is restrained beyond the initiation of the seething thing. Thus, a specially constructed steel formwork that allowed the girder to shrink laterally after it had achieved sufficient strength to support itself was used to cast all four beams. The formwork consisted of three parts, the inside form, which helped the deck and the inside of the webs, and two outside for states that supported the overhang. The outside inside document consisted of a stationary center post and articulating arms supported from below by turnbuckles. The block on the underside of each overhang was formed from foam-covered plywood boxes.

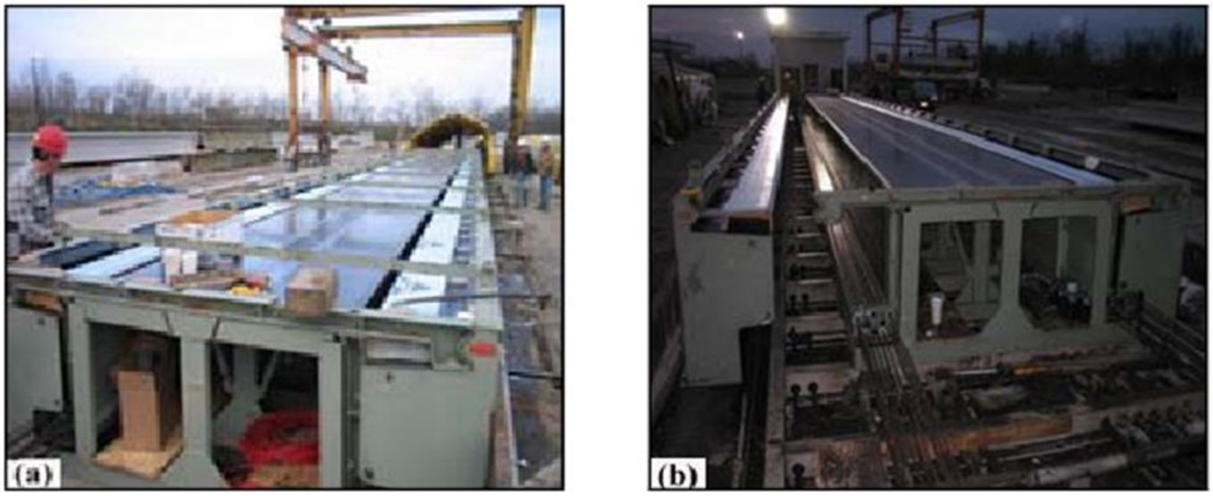

Fig 5: girder framework

Results:

S.No	Static flow	Dynamic flow
Girder 1	195-200	235
Girder 2	200-210	220-240
Girder 3	200-205	230-235
Girder 4	200	230

Table 5 the mixer used for the mixing of UHPC

Conclusions:

The shrinkage is closely tied to the temperature conditions surrounding the girder and showed more shrinkage at higher temperatures. Even factors such as the variations in the temperature of supplemental heating inside the tent and proximity to steam conduits affect the shrinkage rates. The concrete at some locations in the girder has also shown variable shrinkage and the restraint to the concrete, mainly due to the formwork, also influences the shrinkage rates. Mixing of different age premixes also affects the shrinkage rates. The other setting times of the premixes release quite a lot of the restraint. The transfer length was in the region of 9 in. to 10 in. Lateral flexure within the bulb due to the asymmetric prestress pattern, which produces additional bending strains, may be responsible for the compressive stresses in the outer bulb being more than the predicted maximum possible theoretical pressure. The Gaussian curve fits well with the prestress strain pattern observed in the girder bulbs. There were no significant creep effects on the girder almost two months after the application of prestress.

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