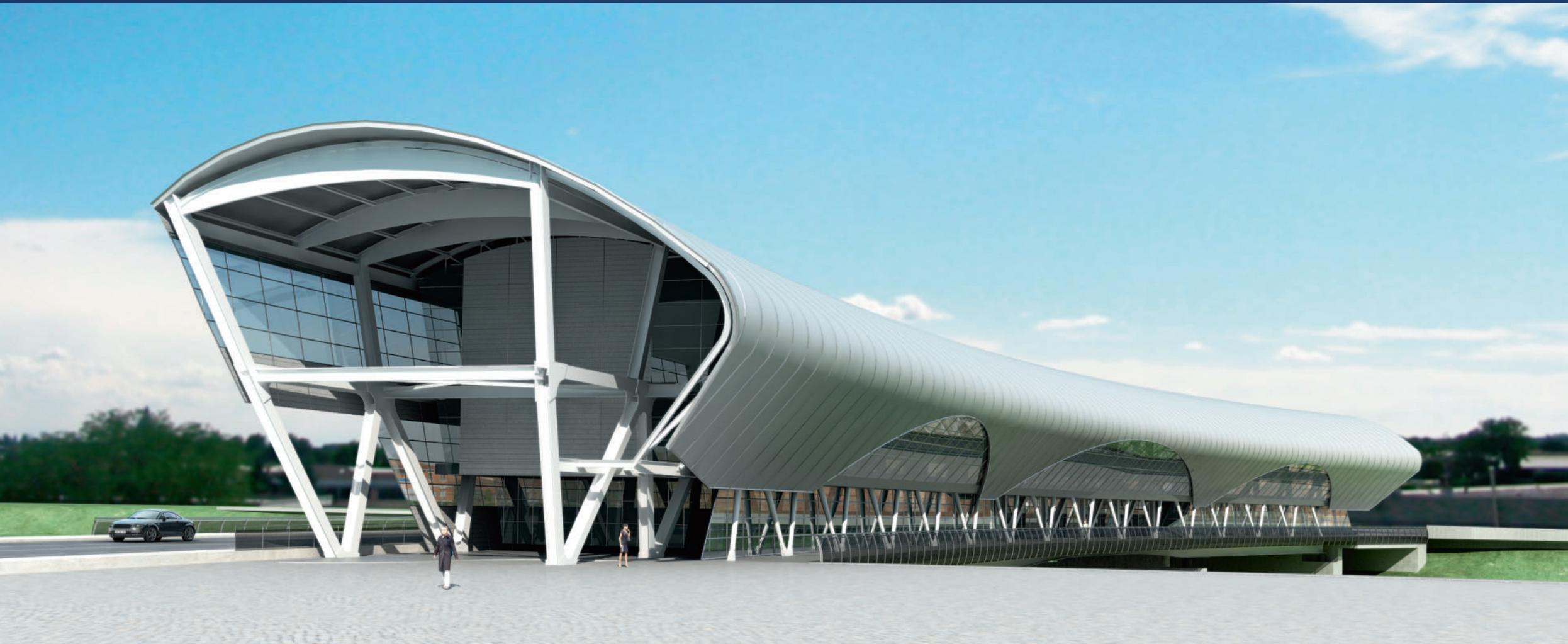


Bridge Maintenance, Safety, Management, Resilience and Sustainability

Editors

Fabio Biondini & Dan M. Frangopol



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Acknowledgments

The Editors are extremely grateful to all people who contributed to the organization of the IABMAS 2012 Conference and to the production of this volume. Particularly, the Editors would like to express their sincere thanks to all the authors for their contributions, to the members of the International Scientific Committee and the National Advisory Committee for their role in ensuring the highest scientific level of the Conference, and to the members of the National Organizing Committee for the time and efforts dedicated to make IABMAS 2012 a successful event.

Moreover, the Editors wish to thank all organizations, institutions, and authorities that offered their sponsorship. At the institutional level, a special acknowledgment has to be given to the Politecnico di Milano, for organizing and co-sponsoring this Conference along with the International Association for Bridge Maintenance and Safety (IABMAS), as well as to the Department of Structural Engineering for endorsing and supporting the Conference organization.

IABMAS 2012 has been conceived, planned, and developed in close consultation and cooperation with several individuals. Principally, the Editors wish to express their sincere gratitude to Pier Giorgio Malerba, Honorary Chair of the Conference, and Franco Bontempi, co-Chair of the International Scientific Committee, for their valuable and continuous support to the scientific organization of this Conference.

The Editors are also extremely thankful to Airong Chen, Hyun-Moo Koh and Richard Sause, co-Chairs of the International Scientific Committee; Marcello Ciampoli, Andrea Del Grosso and Claudio Modena, co-Chairs of the National Advisory Committee; Elsa Garavaglia and Luca Martinelli, co-Chairs of the National Organizing Committee; Alessandro Palermo, Secretary of the International Scientific Committee.

Finally, the Editors wish to express their warmest appreciation to Elena Camnasio and Andrea Titi, who led the Scientific Secretariat and provided a huge amount of effective teamwork, and Roberta Stucchi, who designed, developed and maintained the Conference website with praiseworthy dedication and technical skill. Special thanks are due to Stella Pennini, Laura Manenti, Marta Padovan, Miriam Zanelli, and all team of Incentives & Congressi, who professionally managed the Organizing Secretariat with outstanding expertise, commitment and enthusiasm which have been very important for the successful organization of this Conference.

Preface

The number of deteriorating bridges is increasing worldwide. Costs of maintenance, repair and rehabilitation of these bridges far exceed available budgets. Maintaining the safety and serviceability of existing bridges by making better use of available resources is a major concern for bridge management. Internationally, the bridge engineering profession continues to take positive steps towards developing more comprehensive bridge management systems. It was therefore considered appropriate to keep the tradition of the IABMAS conferences and bring together all of the very best work that has been done in the field of bridge maintenance, safety, management, resilience and sustainability at the Sixth International Conference on Bridge Maintenance, Safety and Management (IABMAS 2012), held in Stresa, Lake Maggiore, Italy, from July 8 to 12, 2012 (<http://www.iabmas2012.org>).

The First (IABMAS'02), Second (IABMAS'04), Third (IABMAS'06), Fourth (IABMAS'08), and Fifth (IABMAS 2010) International Conference on Bridge Maintenance, Safety and Management were held in Barcelona, Spain, July 14–17, 2002, Kyoto, Japan, October 18–22, 2004, Porto, Portugal, July 16–19, 2006, Seoul, Korea, July 13–17, 2008, and Philadelphia, PA, USA, July 11–15, 2010, respectively.

IABMAS 2012 has been organized on behalf of the International Association for Bridge Maintenance and Safety (IABMAS) under the auspices of Politecnico di Milano. IABMAS encompasses all aspects of bridge maintenance, safety and management. Specifically, it deals with: health monitoring and inspection of bridges; bridge repair and rehabilitation issues; bridge management systems; needs of bridge owners, financial planning, whole life costing and investment for the future; bridge safety and risk related issues, including economic and other implications. The objective of IABMAS is to promote international cooperation in the fields of bridge maintenance, safety, management, life-cycle performance and cost for the purpose of enhancing the welfare of society (<http://www.iabmas.org>).

The interest of the international bridge engineering community in the fields covered by IABMAS has been confirmed by the significant response to the IABMAS 2012 call for papers. In fact, over 800 abstracts from about 50 countries were received by the Conference Secretariat, and approximately 70% of them were selected for final publication as technical papers and presentation at the Conference within mini-symposia, special sessions, and general sessions. Compared to IABMAS 2010 the number of papers scheduled for presentation at IABMAS 2012 has increased from 511 to 555.

Contributions presented at IABMAS 2012 deal with the state of the art as well as emerging concepts and innovative applications related to all main aspects of bridge maintenance, safety, management, resilience and sustainability. Major topics covered include: advanced materials, ageing of bridges, assessment and evaluation, bridge codes, bridge diagnostics, bridge management systems, composites, damage identification, design for durability, deterioration modeling, earthquake and accidental loadings, emerging technologies, fatigue, field testing, financial planning, health monitoring, high performance materials, inspection, life-cycle performance and cost, load models, maintenance strategies, non-destructive testing, optimization strategies, prediction of future traffic demands, rehabilitation, reliability and risk management, repair, replacement, residual service life, resilience, robustness, safety and serviceability, service life prediction, strengthening, structural integrity, and sustainability, among others.

Bridge Maintenance, Safety, Management, Resilience and Sustainability contains the lectures and papers presented at IABMAS 2012. It consists of a book of extended abstracts and a DVD of full papers of 555 contributions, including the T.Y. Lin Lecture, nine Keynote Lectures, and 545 technical papers from 40 countries. This volume provides both an up-to-date overview of the field of bridge engineering and significant contributions to the process of making more rational decisions in bridge maintenance, safety, serviceability, resilience, sustainability, monitoring, risk-based management, and life-cycle performance using traditional and emerging technologies for the purpose of enhancing the welfare of society. The Editors hope that these Proceedings will serve as a valuable reference to all concerned with bridge structure and infrastructure systems, including students, researchers and engineers from all sections of bridge engineering.

Fabio Biondini and Dan M. Frangopol
Chairs, IABMAS 2012

Milan and Bethlehem, April 2012

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Ankara-Istanbul Railway High-Speed Train Project, Construction of Viaduct V4 of 2400 Meters

Süleyman Uluöz, Selahattin Düzbasan & Mustafa Camcıo lu

Ilgaz İnaat Tic.Ltd. ti. (Construction) Ankara, Turkey

Erol Yakıt

Railone Ilgaz Demiryolu Sis.Ürt. th. hr.Ltd. ti.(Concrete sleeper) Ankara, Turkey

ABSTRACT: Construction of Viaduct V4 of 2,400 meters, located on Ankara-Istanbul Railway High-Speed Train Project and one of longest viaducts of Turkey, has been accomplished on 2007.

175.000 m³ of concrete in various classes and compatible with TS EN 206-1 standard criteria, 25.000 tons of iron and 1.000 tons of pre-stressing steel cord have been used on viaduct construction.

1,100 ea bored piles, 67 ea foundation, 67 ea piers and 792 ea pre-stressed precast beams have been constructed and executed within the scope of project.

Sulfate resisting cement has been used for construction of bored piles and foundations, due presence of sulfate risk on main soil on the construction site.

CEM I cement has been used for construction of piers, pre-stressed beams, floor concrete layers, protective concrete layers, cable ducts and front elements, which do not have any risk to contact with main soil on the construction site. Concrete designs in C 25/30, C 30/37 and C 40/50 classes and envisaged to be used in the project were set out as the next step, after determination as primary step that;

- Aggregate used was compatible with TS 706 EN 12620
- Cement used was compatible with TS EN 197 6 1
- Concrete mixture water was compatible with TS EN 1008
- Concrete chemicals were compatible with TS EN 93462 and ASTM C 494 standard criteria.

It was possible to cast concrete compatible with TS EN 206-1 standard criteria, even on a temperature of 6 °C, due measures taken by taking into account seasonal climatic changes occurred in Polatl, during the last 10 years.

1 INTRODUCTION

V4 Viaduct, which is within the scope of Ankara-Istanbul Railway High Speed Train Project; starts from 14th kilometer after the exit of Polatl, and passes through the Sakarya river and is connected to the main route of the railway.

Due to the precautions taken before the start of the project, it has become possible to continue work for 24 hours per day uninterruptedly even at the unfavorable weather conditions.

The characteristic properties of the project are given at Table 1.

Table 1. Characteristic properties of V4 viaduct.

Length	(m)	2.400
Bored pile	(ea)	1.100
Raft foundation	(ea)	67
Prestressed beam	(ea)	792
Concrete	(m ³)	175.000
Iron	(ton)	25.000
Prestressed steel rope	(ton)	1.000

2 SUBSTRUCTURE WORKS

2.1 Electricity and water depots

Electricity network at the construction site has been supported by generators which are automatically engaged in any case of malfunction.

As a precaution for concrete productions during the cold weather, special heating systems have been placed inside the water depots which are preserved at closed area.

2.2 Site roads

In order that the works to be performed at construction site not to be hindered during rainy days, approximately 10 km length road has been constructed. After 98 % compaction is provided at every layer of the ground, approximately 100.000 ton basalt aggregate has been laid and compressed.

3 CONCRETE PLANT

Within the scope of the project, a fixed concrete plant of 120 m³/h capacity and a mobile concrete plant of 60 m³/h capacity have been established.

Regarding the malfunctions at concrete plants, agreements have been made with 2 ready mixed concrete facilities both of which are located in Polatl., certified by Turkish Standards Institution and making concrete production in accordance with TS EN 206-1.

3.1 Concrete components

Aggregate; at the productions of concrete within the scope of the project, limestone aggregate at 4 different gradation all of which are in conformity with criteria of TS 706 EN 12620 standard have been used.

In order to cut the prestressed steel ropes which are used at prestressed beam in a shorter period of time and in order to prevent adverse effect of crystalline calcite within limestone aggregate over concrete quality, basalt aggregate has started to be used after the production of 50 ea beam.

Cement; regarding the risk of availability of sulfate salts over the construction site ground, sulfate resistant cement has been used at the manufacture of bored pile and construction of foundation.

CEM I 42,5 cement has been used for production of pier, capping beam, bearing and seismic block and pre-stressed beams. 6 ea concrete hoppers with the capacity to stock 550 ton cement have been placed within concrete plants.

Concrete chemical; with respect to the concrete production, high level of water reducing concrete chemical which is in conformity with the characteristics of TS EN 93462 and ASTM C 494 Type F, has been used.

Concrete mixing water; with respect to the concrete production, water, which is in conformity with TS EN 1008, has been used.

3.2 Concrete designing works

In order to prevent the ettringite and alkali - silica reaction at concrete, it has been ensured that the cement to be in conformity with criteria of TS EN 197-1 standard and also the amount of Na₂O, K₂O (total alkali) and SO₃ within the concrete have been continuously monitored. Samples taken from the concrete trial mixtures made in the laboratories have been kept at various weather conditions and then their pressure resistance and tensile strength at bending have been determined.

Concrete mixtures have been prepared again in the presence of technical personnel of Spanish Obrascon Huarte Lain S.A.(OHL) Company which is the contractor of the project and then the concrete mixtures to be used at the project have been determined.

4 PRECAUTIONS TAKEN FOR UNFAVORABLE WEATHER CONDITIONS

4.1 Cold weather conditions

- Regarding the changes in seasonal air conditions at Polatl, for the last 10 years, the site working plans and the precautions to be taken have been determined.
- In the cold weathers, special care has been taken to use aggregates which had been recently prepared at the stone crusher facility.
- Bunker, conveyor band, mixer of the concrete plant has been covered by a special system to prevent the concrete and the components from being affected from unfavorable weather conditions.
- The sections of the water network which are in contact with external environment, concrete chemical depots and water depots have been covered by isolation materials. Heating system has been installed inside the depots.
- Lower section of the aggregate bunker has been taken under protection by a closed system and this section has been heated without giving any harm to the mechanical parts.
- At cold weather conditions, mixture water has been used by being heated up to 50°C.
- Increasing the mixing period of concrete plant mixer, the heat caused by friction of aggregate particles with each other has been utilized.
- Trans mixers have been kept at the closed area and before starting the transportation of the concrete, hot water has been poured to boiler sections and twirled for at least 10 minutes to increase the temperature at the metal components.

As a result of taken precautions, works have been continued in spite of the unfavorable winter conditions shown at Figure 1. (Uluöz et al.2007)



Figure 1. Winter condition at site.

4.2 Hot weather conditions

- Since the temperature of concrete brought to the site is about 80±85 °C, it has been used after being rested at least for 24 hours.
- At the concrete production, the aggregate which was prepared recently by the stone crusher has been used.
- During the concrete production, the mixing period of concrete plant mixer has been decreased.
- At the concrete production, the retarder concrete chemical has been used.
- Temperature of the fresh concrete has been continuously monitored.
- At the prestressed beam production, as a precaution against the ettringite risk, after the concrete, which has been placed in the beam mold, has been rested for 3 hours; it has been subjected to steam cure of which the temperature has been gradually increased and pulverize water has been supplied to steam cure halls.
- The boiler sections of the transmixers have been wrapped by cotton cloth and it has been kept humid all the time.
- The transmixers have been kept at the closed area and before starting the transportation of the concrete, the cold water has been poured to inner parts of the mixers and this cold water twirled for at least 10 minutes to decrease the temperature of metal components.
- In order to prevent the truck mixer operator to add water to the concrete afterwards, the water at trans mixer have been emptied and when the consistency of concrete is not proper, redosing has been made.

5 PRECAUTIONS TAKEN TO COMPLETE THE PROJECT ON PLANNED PERIOD

The following precautions have been taken in order the project to be completed on planned period.

- Trainings have been given to the employees regarding the problems they may meet during the works.
- Solution teams have been set up about problems which will delay works at the job site and problems have been solved by brain storming studies.
- Engineers and foremen who are in charge at projects of Ilgaz Construction located at Kazakhstan and Turkmenistan have been held in charge of the project for some periods of time.
- Reinforcements to be used at the construction of bored pile; have been made by machines which have been equipped by robot technologies and the spiral steps and reinforcement diameters work at the millimeter precision.
- Among viaduct line, subcontractors at different branches have been employed.
- In order the power failures not to delay works; generators with sufficient capacities have been made available at concrete plant, precast production area, different sections of viaduct construction routes and social facilities.
- In order to meet water required for concrete production and water cure, water depots having internal heating systems have been supplied.
- As a precaution against malfunctions at concrete factories to delays of concrete productions, 6 ea cement silo having the capacity of 550 ton have been placed at fixed and mobile concrete plant and also connections with alternative cement factories have been established.
- In order to prevent delay of precast beam production due to a possible malfunction at steam generator, 1 ea steam boiler has been waited as backup.
- 1 ea concrete pump has been waited as backup in order to be used when concrete pump which is used for concrete productions is broken.
- In order to prevent trans mixer operators to add water afterwards, water at trans mixer have been emptied and when the consistency of concrete is not proper, redosing has been made.

6 LABORATORY WORKS

Samples taken continuously from the iron and concrete used within the scope of project were tested in

- Construction inspection authority's laboratory.
- Company's construction site's laboratory.
- Witness laboratories holding TS EN ISO/IEC 17025 Certificate, in terms of compatibility of fabrication quality with standards and contract's technical specifications.

Solution teams established during execution of the project, within the scope of the company's ISO EN 9001:2000 Quality Management System, to solve problems occurred and to prevent repetition of same incidents and carry out studies within this frame, have performed brain storm studies.

7 PRESTRESSED PRECAST BEAM PRODUCTION

A fixed facility has been established for the manufacture of 792 ea I 195 type prestressed precast beam to be used within the scope of the project. At the facility, 2 production halls which are able to produce 4 ea beams simultaneously have been constructed and hydraulically foldaway molds have been used in the production. Prestressed beam production has been realized in 3 phases.

At the 1st phase; After the reinforcement is placed to the molds which are prepared for production in accordance with the project, pre-stress process over pre-stressed steel ropes placed to the sections specified within the project has been applied.

At the 2nd phase; While the concrete is gradually filled inside the mold, 12 ea surface vibrators over the beam mold have been operated to ensure the placement of the concrete inside the mold.

At the 3rd phase; Steam cure has been gradually applied over the concrete inside the mold for 12 hours in accordance with TS 3648 standard. After it has been determined that the pressure over concrete samples placed at steam halls is 37,5 N/mm², the prestressed steel ropes have been cut off.

The beams taken out of mold have been transported to the preliminary stock area and subjected to water cure. At Figures 2,3 and 4 the production phase are shown.



Figures 2,3,4. Pre-stressed precast beam production.

7.1 Concrete quality at the prestressed precast beam

Concrete Quality; at beam production, C 40/50 class concrete has been used. During production, 12 ea cube samples having 15 cm diameters have been taken and 6 of these samples have been subjected against steam curing in order to determine transfer resistance. Other samples have been excluded in order to determine their 7 days and 28 days pressure

resistances. During production of prestressed beams, 9700 ea concrete cube samples have been taken and their pressure resistances have been determined.

At the evaluation of test results, it has been determined that pressure resistance of concrete which has been used at beam construction was 23,8 % more than the resistance of the project. Pressure resistance results taken from samples produced during February 2007 have been given at Table 2.

Table 2. Pressure resistances of concrete.

Age of concrete sample	Amount of sample	Mathematical average N/mm ²	Standard deviation N/mm ²
End of the steam cure	243	39,9	1,1
7 days	243	50,8	1,2
28 days	243	61,9	0,9

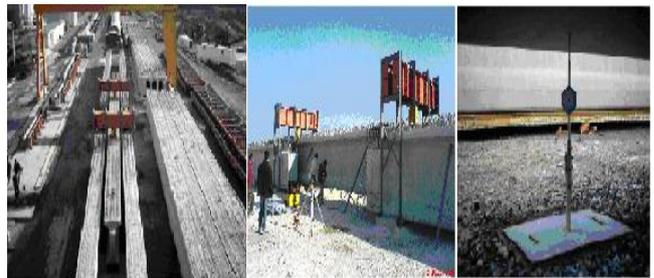
7.2 Loading test for prestressed beams

Pre-stressed beams loading test was performed in 2 phases.

At the 1st phase; after the test load had been applied over 1/3 and 2/3 sections of the prestressed beams as shown in Figures 5,6 and 7 the deflection measurement had been performed after waiting for 5 minutes.

At the 2nd phase; after the loads over beams had been removed gradually, the current deflection had been measured.

At the measurements performed, it had been determined that more than 95 % of the deflection had been recovered. (Uluöz et al. 2008)



Figures 5,6,7. Loading test for pre-stressed beams.

8 WORKS WHICH HAD BEEN PERFORMED AT THE VIADUCT S TE AREA

Within the scope of the project; approximately 175.000 m³ concrete had been used at different classes; 25.000 m³ of which has been used for pre-stressed beam production and 150.000 m³ of which has been used for other structures.

8.1 Bored pile

Within the scope of the project, in total, 1100 ea bored piles had been manufactured as 16 ea for each raft foundations. In order that the bored piles, of which the construction phases are given in Figures 8, 9 and 10 to be constructed within the scheduled period, 7 subcontractors had made a continuous work for 24 hours per day by using 10 ea bored pile machinery.



Figures 8,9,10. Images from bored pile work.

8.1.1 Concrete quality at the bored pile

At the construction of bored pile, C25/30 class concrete has been produced by using cement resistant against sulfate. At table 3, pressure resistances of concrete which is used for the construction of number 1, 2 and 3 bored piles. At the evaluation of test results, it has been determined that pressure resistance of concrete which has been used at bored pile construction was 25,0 % more than the resistance of the project.

Table 3. Pressure resistances of concrete.

Cement class		Sulphate resistant cement	
Bored pile no	Concrete class	Pressure resistance N/mm ²	
		7 Days	28 Days
1	C 25/30	28,6	37,5
2		25,0	34,7
3		27,9	36,5

8.1.2 Bored piles quality

Quality tests of bored piles have been checked by performing integrity test and bored pile loading test. Integrity test as shown on Figures 11,12 and 13, bored pile loading test as shown on Figures 14, 15 on bored pile constructions.



Figures 11,12,13. Bored pile integrity test.



Figures 14,15. Static loading test on bored pile.

8.2 Foundation

At the construction of viaduct, 67 ea foundations of which volumes were in between 400 ó 650 m³ had been made in 4 phases.

1st phase; in order foundations to be excavated 4 excavators and 20 dump trucks had continuously operated for 24 hours per day.

Special attention has been given for capping concretes of bored piles not to be broken during excavation of foundation.

2nd phase; capping concretes of bored piles have been broken and reinforcements have been cleaned by pressurized air and water.

Besides, underground water at the foundation has been discharged by motor pumps.

3rd phase at the preparation of foundation reinforcements, 4 iron contractors and 170 iron masters have worked in shift for 24 hours and approximately 110 ton iron has been used for each foundation.

4th phase; after necessary cleaning operations have been made by pressurized air at inner sections of the foundation which is ready for concrete pouring, concrete pouring has been realized.

During concrete pouring, 2 ea concrete pumps, 10 ea transmixers have been used and vibration has been applied at 3 different sections of foundation. During concrete pouring, necessary precautions have been taken in order to discharge water which is present at the foundation and in order to prevent cold joint at concrete.

8.2.1 Concrete quality at the foundations

At the construction of the foundations, C 25/30 class concrete has been produced by using sulphate resistant cement. Special attention has been given the consistency of the concrete to be 10-15 cm and at the cases when concrete consistency is low, the consistency has been adjusted by redosing. 1 set of sample has been taken from the 50 m³ concrete produced and their concrete resistances for 7 days and 28 days have been determined.

At the Table 4, the pressure resistances of the concrete used at different levels of foundation which was constructed at 10.11.2006 are given. Construc-

tion phases of foundation have been given at Figures 16, 17 and 18.

Table 4. Pressure resistances of concrete.

Concrete class		C 25/30			
Super plasticizer		% 0,7			
Retarder		% 0,3			
Cement class		Sulphate resistant cement			
Pressure resistance N/mm ²	7 days	27,5	28,5	25,6	30,8
	28 days	33,6	34,6	33,5	36,7



Figures 16, 17, 18. Construction phases of foundation.

8.3 Pier

2 ea elevations as right and left for 67 ea foundations have been made for the project. Piers have been performed as 4 meter grades and approximately 10 ton iron has been used for each grade. At the production of piers, 2nd concrete pump had been waited as spare. Construction phases of pier have been given at Figure 19.



Figure19. Construction pier.

8.3.1 Concrete quality at the pier

At the construction of the pier, C 25/30 class concrete has been produced by using CEM I cement. Special attention has been given the consistency of the concrete to be 10-15 cm and at the cases when concrete consistency is low, the consistency has been adjusted by redosing. 1 set of sample has been taken from the 50 m³ concrete produced and their concrete resistances for 7 days and 28 days have been determined.

At the table 5, the pressure resistances of the concrete used at different levels of pier which was constructed at 14.11.2006 and 25/11/2006 are given.

Table 5. Pressure resistances of concrete.

Concrete class		C 25/30			
Date of taking the concrete sample and its age		Grade of the pier			
		1.		2	
		Left	Right	Left	Right
Date of receiving		14.11.2006		25.11.2006	
Pressure resistance N/mm ²	7 days	25,1	27,1	32,9	34,5
	28 days	34,0	38,6	38,7	40,6

8.4 Capping beam, bearing and seismic block

At the project it is requested the capping beam and seismic block to be at C 25/30 class, the bearing to be at C 30/37 class.

- Due to the adverse weather conditions,
- In order the beams to be assembled on time by shortening the period of mold opening,
- In order to complete the project on time, C 30/37 concrete has been used.

At some sections of *capping beam* project, since the reinforcements were so close, concretes at different gradations have been used.

8.4.1 Concrete quality at the capping beam, bearing and seismic block

Since adverse weather conditions were taken into consideration, samples taken from the capping beam, bearing and seismic block concretes have been waited for 24 hours at site conditions and then their 7 days and 28 days concrete pressure resistances have been determined. At Table 6 pressure resistances over samples received from capping beam and bearing at different dates are shown. At Figures 20, 21 and 22 the production stages are shown.

Table 6. Pressure resistances of concrete.

Place where the concrete was used	Concrete class	Pressure resistance N/mm ²	
		7 days	28 days
Capping beam-19	C 25/30	31,4	41,4
Capping beam- 14		35,2	50,3
Bearing - 8	C 30/37	34,6	53,2
Baring - 47		39,4	52,2



Figures 20, 21, 22. Works capping beam.

8.5 Installation of prestressed beams

Before starting to the construction of the project, it had been planned to use launching girders which were already available at our construction machine fleet. However later it has been decided to use cranes for productions regarding geometric shapes of end frames and land conditions. After sliding and fixed supports are installed over support concrete bases, installations of beams have been performed by using 250 ton capacity crawler crane with cage boom and a 400 ton capacity telescopic mobile crane.

At Figures 23 and 24 installations performed by crane are shown.



Figures 23, 24. Pre-stressed beam installation.

9 SUPERSTRUCTURE WORKS

Laid concrete; regarding unfavorable weather conditions, C30/37 concrete had been used instead of C 25/30 class which had been mentioned in the project and after the concrete layer was covered by a special system, inside of it has been heated by a special method.

Cable channels and eaves; Cable channels and eaves have been manufactured at Yenice and Pozant, Pre-cast Facilities within the body of Ilgaz Construction Company.

Isolation; after the concrete for pedestrian walk way were poured over V4 viaduct, isolation had been made over 25.000 m² area by using insulating material.

Protective concrete; After the steel mesh is placed over insulating material, a protective concrete of C30/37 class at 5 cm thickness has been laid and ballast.

Sleeper; 680.000 ea B 70 type traverse which are required in the project and which are proper for UIC 60 rails and approximately 7.200 ea traverse which are required for V4 viaduct have been supplied from the facilities of RAIL. ONE GmbH that are located at Germany, Hungary and Romania. (Uluöz et al. 2008) At Figures 25, 26, 27 are showing the works in this phase.



Figures 25,26,27. Superstructure works.

10 CONCLUSION

Since Top management of Ilgaz Construction;

- Had continuously monitored all phases of the project and had solved all bottlenecks on time.
- The mobilization had been completed before the scheduled date.
- Spares of equipments which have a direct affect over the production had been made available all the time.
- A high level of coordination had been established in between Project management and employees.
- Information transmission had been made on time.
- All personnel had worked in a devoted manner.

The project had been completed in a very short period of time as 7 months despite of adverse winter conditions.

At 26.04.2007, test drives had been started over Ankara- Istanbul High Speed Train Project V4 Viaduct. At Figures 28, 29 the opening ceremony performed after the completion of the project has been shown. At Figure 30 general view of the viaduct has been shown.



Figures 28,29. The opening ceremony.



Figure 30. General view.

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