Evaluación de un puente en Ensenada, Provincia de Buenos Aires, Argentina
Assessment of a bridge in Ensenada, Buenos Aires Province, Argentina

V. G. Rosato
L. P. Traversa
F. H. Iloro
R. A. García
J. D.Sota

LEMaC, La Plata, vrosato@frlp.utn.edu.ar
LEMIT, La Plata, Buenos Aires, Argentina, direccion@yahoo.com.ar

GIICMA -UTN Universidad Tecnológica Nacional -Facultad Regional Concordia, Concordia, E.R., ARGENTINA -jdsota@gmail.com

ABSTRACT

The bridge over the mouth of Villa Elisa channel, in the city of Punta Lara (Ensenada district, Buenos Aires Province, Argentina) was built during the 70's decade and is located on the margin of Río de La Plata in an area surrounded by wetlands and subtropical forest included in the Province Natural Reserve "Selva Marginal". It is subjected to intense traffic, especially during the weekends because it is an area used for fishing, hiking and camping, along with weather factors like storms and river flooding. Therefore, its maintenance status is assessed after 50 years in service, so visual and photographic inspections were performed, carbonation profile was measured, and concrete samples were obtained for water absorption and compression resistance. Agents of biological deterioration were registered, too. Contact water was also sampled to test pH, conductivity, hardness, sulphate and chloride in order to assess the environmental conditions and its potential aggressiveness towards concrete. With these data, the remaining life cycle is assessed in order to recommend actions to improve it and increase the sustainability of the concrete.

Keywords: bridge, pathology, life cycle assessment, environmental conditions, agents of deterioration

INTRODUCTION

The concrete bridge over the mouth of Villa Elisa channel, in the city of Punta Lara (Ensenada district, Buenos Aires Province, Argentina) was built during the 70's decade to replace an older bridge and is located on the margin of Río de La Plata in an area surrounded by wetlands and subtropical forest included in the Province Natural Reserve "Selva Marginal" (Figure 1). It is subjected to intense traffic, with an estimated annual average of 4240 vehicles /day (Oviedo & Brizuela, 2013) , as well as weather factors like storms and river flooding. These factors, together with biological agents may affect the materials and therefore, for safety reasons, the concrete`s performance and its maintenance status is assessed after 50 years in service and compared with samples remaining from the old bridge.

MATERIALS AND METHODS

Description of the study area

Punta Lara is a town of the Ensenada district in Bue-nos Aires Province, Argentina, located along the coast of Río de La Plata and its main development happened during the 40's decade, with the building of the school, police station, church and beach club (Delâge et al., 2011).

It was conceived as a popular recreation resort, taking advantage of the river's beaches, so the locality's growth took place especially along the avenue that follows the coast along Río de La Plata and crosses different bridges, until it ends in the Northern limit in the place called as "Boca Cerrada" next to the Province Park "Selva Marginal". This is a place that receives many visitors, especially during the weekends because the area is used for fishing, picnic and camping.

Figure 1. Bridge over the Villa Elisa channel at Boca Cerrada, Punta Lara.

Sampling and material tests

Visual and photographic inspections were performed, and concrete samples were obtained to be tested in the laboratory for water absorption and compression resistance, as well as measurement of carbonation profile with phenolphthalein. SEM observations at 1500 X and Hg intrusion porosimetry were used to study the microstructure, since these factors affect mortar and concrete durability. When fungi, lichens and other microorganisms are considered, the presence of pores with a diameter wider than 10 µm allows a faster colonization by such organisms (Prunell et al., 2012), so the pore size distribution must be also kept in mind besides general porosity.

Water quality tests

Contact water was also sampled to test pH, hardness, sulphate and chloride in order to assess the environmental conditions and its potential aggressiveness towards concrete.

Study of biological agents

Agents of biological deterioration were registered, too. Lichens were collected and observed under stereoscopical and optical microscope, and after studying the hystochemical reactions with KOH and sodium Hypochlorite, they were determined with taxonomic keys (Rosato y Garcia, 2014)

RESULTS

Description of the bridge

The bridge is located in an environment classified as A2 by CIRSOC norms due to the mean temperature of 16°C, average of humidity of 70 % and precipitations of 1100 mm/year. It has a structure called a "beam-bridge" with columns in a line supporting a beam that in turn provides support for the concrete slabs covered by the asphalt pavement, typically used in the 70's, having a better performance during their service life (Ercoli et al. 2015).

Columns and beams do not show fissures, although there is evidence of weathering in the submerged part of the columns (Figure 2).

There is also evidence of corrosion of the metal bars, but no damage caused by the expansion of the iron oxides (Figure 3): there is no material loss or exposed metal bars. The concrete slabs and the asphalt pavement have no important cracks or fissures that could endanger the structure.

Figure 2. Detail of a column.

Figure 3. Detail of the orange staining cause by metal oxides.

Material tests

The mortar was prepared with normal Portland cement, siliceous pebbles with diameters between 6 and 25 mm, and siliceous- feldespatic sand.

According to the performed tests, mortar is almost carbonated: the outer layers are non reactive and carbonated, whereas the rest of the material inside only has a slight reaction to phenolphtaleine, (Figure 4)

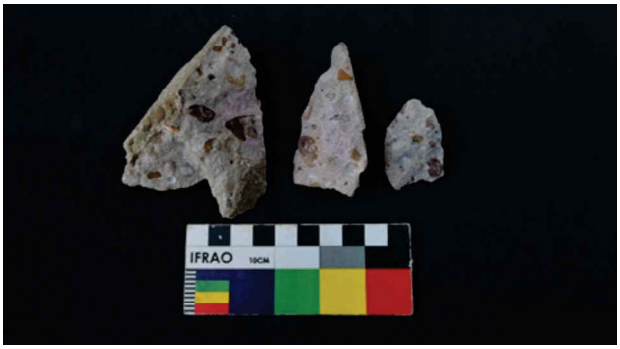

Figure 4. Mortar samples, tested with phenolphtaliene (on the right, non- tested piece as blank). Note the faint pink reaction.

The density of the material is 2.29g/cm; the water absorption rate is 5% and the porosity is 11.08%. As a comparison, the material of the old bridge has a density of 2.1, the water absorption rate was 11.91 and the porosity is very high: 24%.

Electron Dispersive Spectrometry (EDS) results indicate that the cement mortar still has a good calcium proportion (Table 1), which can also be noticed in the spectrum (Figure 6).

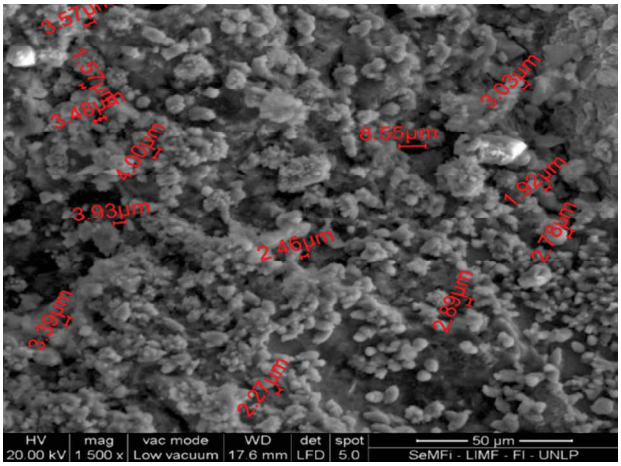

Figure 5. Pore measurements of the mortar observed at 1500 X.

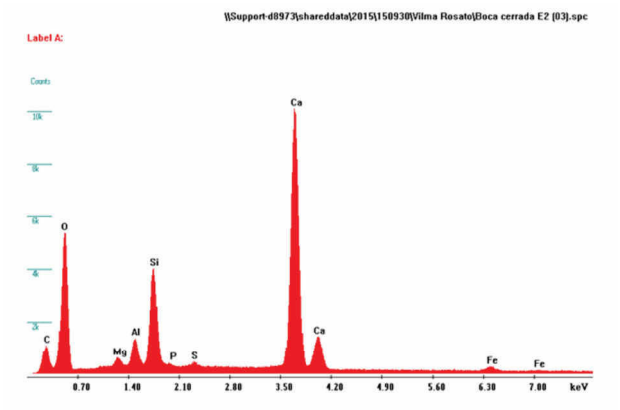

Figure 6. EDS Spectrum of a mortar sampl.

Element	C	O	Mg	Al	Si	P	S	K	Ca	Fe
%	10,85	47,4	1,29	2,67	6,66	0,31	0,41	0,23	28,8	1,37

Table 1: EDS Results. Compression resistance tests varied between 13 and 16 MPa.

Water tests

The results of the water tests were as follows: pH 6.5; hardness 0.02%; sulphate < 0.01 and chloride 55 mg/dm^3; this means the water is not aggressive for the mortar.

Organisms observed

The only organisms observed were lichens (Figure 7): *Xanthoplaca austrocitrina, Caloplaca teicholyta and Staurothele monosporoides*, three species commonly found on mortars in Buenos Aires Province (Rosato & Garcia, 2014). There are no ferns or plants.

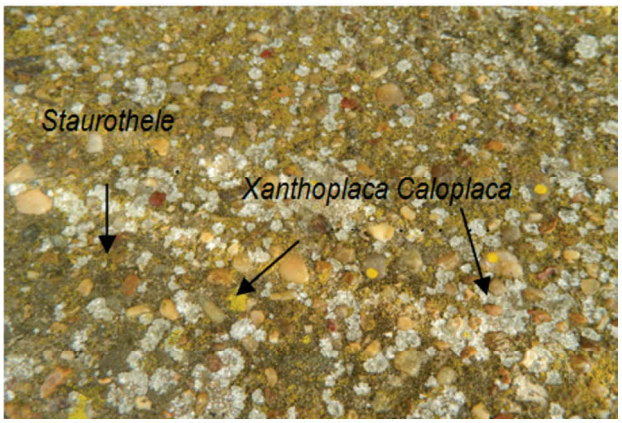

Figure 7. Detail of a column.

CONCLUSIONS

There are orange-red stained patches under the concrete slabs, but no cracks or fissures. The columns have lost material from the superficial layer. This is attributed to a mechanical action of the water, because the chemical analysis proved it has almost inexistent amounts of potentially aggressive substances. However, the mentioned loss did not cause a significant reduction of the columns' section.

In spite of the mentioned problems the bridge is in a good general condition when considering its age and intense use, mainly because of two factors: good material quality and design.

In fact, the results of the tests performed are consistent with a compact, low porosity and resistant mortar which has been correctly designed and built with good practice. The compression resistance seems low, but at that time, concrete was calculated to obtain such values. As a consequence of the lack of fissures and low porosity, there is a low coverage and diversity of lichens and no plants affecting the structure.

As for the design, "beam-bridges" have a better stability and performance regarding loads (Ercoli & al., 2015) but this should be confirmed in this case with load and dynamic load tests.

REFERENCES

Delage R., Lofeudo R. & Rosato V. G. 2011. Estado de conservación del edificio ex Jockey Club de la Provincia de Buenos Aires en Punta Lara, Ensenada. Ciencia y Tecnología de los Materiales 1: 50-61

Ercoli, N.M., Peralta M.H., Gerbaudo C., La Malfa, S. 2015. Monitoring of structures from civil worksfor an in-service sustainable performance. In: International Conference on Sustainable Structural Concrete "Sustain Concrete 2015", 15-18 September 2015, La Plata, Argentina

Oviedo, M. & Brizuela L., 2013. Proyecto: Jerarquización de la Costanera de Punta Lara. Trabajo final de grado, Universidad Tecnológica Nacional, Facultad Regional La Plata.

Prunell S., Rosato V. G. y Sota, J. 2011 Ensayos de Deterioro Biológico Acelerado por Acción del Hongo Aspergillus niger en Matrices de Cemento portland con Diferentes Porcentajes de Adiciones. Cinpar 2011, 7º Congreso Internacional sobre Patologías y Rehabilitación de Estructuras, Fortaleza, Brasil, 2 a 4 de Junio de 2011

Rosato, V. G. & García R . A. 2014. Clave de líquenes creciendo sobre cemento y hormigón en la provincia de Buenos Aires, Argentina. Glalia 6(1): 1–14.