

Subject review / Pregledni rad

NEGLECTED MARINE STRUCTURES – THE MIAMI MARINE STADIUM vs. THE RIJEKA TORPEDO LAUNCH PAD STATION

Zapostavljene pomorske građevine –
Pomorski stadion u Miamiju u usporedbi s
riječkom lansirnom stanicom za torpeda

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SUMMARY

Key words: Miami Marine Stadium, Rijeka Torpedo Launch Pad Station, comparison, industrial heritage, reuse

In the last 100+ years of global industrial development, all kinds of different industries were placed on city coastlines today forming robust and grey waterfronts. Some waterfronts kept track with world challenges and changes while others were passed over and forgotten. This paper will present two marine facilities with similar construction elements but opposing exploitation purposes; the Miami Marine Stadium and the Rijeka Torpedo Launch Pad Station. The aforementioned was the purpose-built facility of the mid-1960s with recognized architectural value, which was designed and constructed for the entertainment industry; while the latter was the result of the modern approach to industrial research and development (R&D) processes during the period of the 1930s and 1940s. The Torpedo Launch Pad Station represents the peak of R&D process in the torpedo industry, which was born in Rijeka, where the emphasis was on the facility's functionality rather than aesthetics. For the last several decades, both facilities have been abandoned and left at the mercy of time and nature. Despite their age differences and reasons of their abandonment, these facilities can be compared. This paper will give such comparisons as well as the construction aspect for their protection and reuse. These facilities are unique structures and of important industrial heritage to both the cities of Miami and Rijeka and must be saved for future generations

INTRODUCTION

In the last 100+ years of world industrial development, all kinds of different industries were placed on the city shores, forming today's robust and grey waterfronts. Some waterfronts kept track with world challenges and changes while others were stepped over and forgotten. Two unique facilities as monuments of two different waterfronts will be compared in this paper; the Miami Marine Stadium and the Rijeka Torpedo Launch Pad Station.

The city of Miami is located on the Atlantic coast in southeastern Florida and the county seat of Miami-Dade County, the most populous county in Florida and the eighth-most populous county in the United States with population of 2,500,625 (Wikipedia, 2012). Miami is a major center and a leader in finance, commerce, culture, media, entertainment, arts, and international trade, which was in 2012 classified as an Alpha-World City (GAWC, 2010) in the World Cities Study Group's inventory. In such exquisite town among huge varieties of facilities one facility, the Marine Stadium, was erected for entertainment industry purposes. The Marine Stadium and Basin are located on Virginia Key-on the way to Key Biscayne and only five minutes from downtown of the city of Miami (Figure 1).



■ **Figure 1** The Miami waterfront and Key Biscayne (photo courtesy of Friends of Marine Stadium)

The city of Rijeka, on the contrary, is the main Croatian port on the Adriatic Sea, situated on the shore of Kvarner bay where the Mediterranean is closest to the countries of middle Europe, with the population ten times smaller than Miami County. None the less, many of the world's new technologies started in Rijeka, including high-pressure technology, the first use of the gyroscope, systematic

research and development of new products, torpedo invention and production, and so on.

Being in background of Kvarner, with Dinaric Alps at lower altitude, Rijeka is the easiest crossover from sea side deeper into the land, towards European countries. Good geographical position of Rijeka provided good communication post, which was first noticed by Romans and Greeks, and can be found in charts of famous chart maker Claudius Ptolemaeus. Industrial developments in Rijeka are strictly connected with developments which followed the Industrial Revolution such as development of steam engine. In the late years of 19th century, town grew rapidly and good geo-communication position helped Rijeka to become industrial centre and important sea port of that time (Marović, Završki and Car-Pušić, 2009a; Marović, Završki and Car-Pušić, 2009b).

The last decades have not been easy for many transitional countries, and Rijeka was not an exception. Several industries with more than hundred years of successful working life encountered business troubles and eventually went bankrupt. These last few years of global crisis and recession pushed the idea of reuse of facilities that have been neglected for years further down the priorities list, making the reuse of these facilities even more improbable. Aforementioned should by no means present a barrier in preserving important monument of world's industrial heritage such as Rijeka Torpedo Launch Pad Station.

This paper will present two marine facilities with similar construction elements but opposite exploitation purposes as well as the latest on and off site investigations and construction aspect of protection and reuse.

BRIEF HISTORY OVERVIEW OF FACILITIES

Miami Marine Stadium

Built in 1963, Commodore Ralph Middleton Munroe Miami Marine Stadium (Miami Marine Stadium) was the first purpose-built venue for powerboat racing in the United States (World Monuments Fund, 2009). The signature element of architect Hilario Candela's design is the stadium's concrete hyperbolic paraboloid roof with 20 m long cantilever (Figure 2). Such element places Miami Marine Stadium among buildings with one of the longest nontruss cantilever roof spans in the world. Another unusual feature of the design is that about one-third of the Stadium is built over the water on concrete piers. This 1960s concrete structure became the modernist landmark on the Miami, FL, waterfront.



■ **Figure 2** *The Miami Marine Stadium – aerial view (photo courtesy of Friends of Marine Stadium)*

The Stadium is a cast-in-place concrete structure consisting of five primary structural systems (Brainerd, Tumialan and Bronski, 2011):

- Foundations: concrete piles with pile caps supporting columns, grade beams, and a seawall;
- Ground-level structure: grade beams and structural slabs-on-ground;
- Mezzanine-level structure: slabs and pan joists generally supported by beams and columns but in some cases supported by hangers connected to the grandstand structure;
- Grandstand structure: vomitory and parapet walls, raker beams, tie beams, and columns supporting tread-and-riser seating slabs; and

- Roof structure: eight hyperbolic paraboloid (hypar) shell units joined by a longitudinal post-tensioned diaphragm wall-each hypar shell unit comprises four hypar shells and is supported by three inclined columns – two at the back and one in the interior.

During its 28 years of operation from 1964 to 1992, the 6566-seat stadium, although designed for boat racing, also featured musical performances of every type, boxing, water shows, and community events. During its last few operating years, the Stadium deteriorated as the City of Miami shows less and less interest in managing the facility (Friends of Marine Stadium, 2011).

Shortly after Hurricane Andrew passed through south Florida in 1992, the city of Miami closed the venue, because of concerns about the safety of the structure. Since then, the Stadium has sat vacant, without maintenance, subject to vandalism and prolific graffiti.

Regardless of fact that the Stadium was already closed and vacant, the City alleges that Hurricane Andrew damaged the facility and needed to be demolished for safety reasons (within \$1 million). When the insurance company commissioned an engineering study by Simpson Gumpertz and Heger (SGH), and it went public, opposition to the demolition was organized, and the City backed off. Study showed that the Stadium suffered no damage from Hurricane Andrew and required \$2-3 million in repairs due to lack of investment during its operating period.

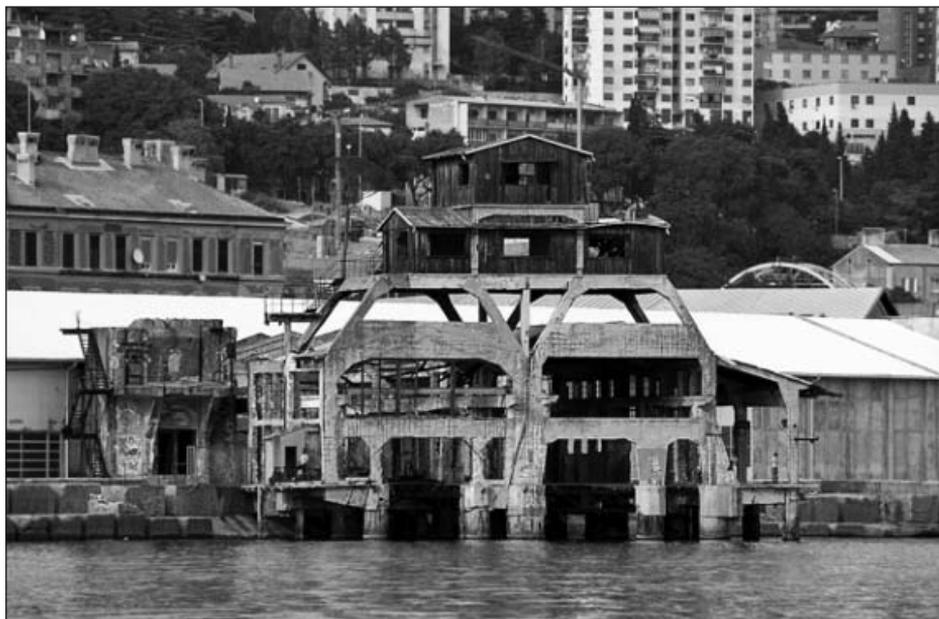
During last two decades, SGH conducted Stadium condition surveys in 1993 and 2009 which were the backbone of people gathering, and citizen organization Friends of Marine Stadium. Over the years, Friends of Marine Stadium build momentum, which not only stimulated local and national magazines and organization to endorse effort to restore Marine Stadium, but also provoked National Trust for Historic Preservation to place the Miami Marine Stadium among “11 Most Endangered Historic Places” in USA. This activism led to the Worlds Monument Fund, the foremost organization worldwide devoted to the preservation of architectural and cultural sites, to name the Miami Marine Stadium to its 2010 Watch List.

Rijeka Torpedo Launch Pad Station

In the 1850s, the new “Metal foundry” represented the beginning of new, modern Rijeka’s metal manufacturing industry, which later became the first producer of ship steam engines and steam iron ships, and where the first torpedo in the world was invented and produced. Smokvina (2006) noticed that two people, Giovanni Biaggio Luppis with an idea, and Robert Whitehead with his engineering research and development skills, were responsible for developing new kind of navy weapon – the torpedo.



■ *Figure 3 Torpedo Launch Pad Station and former Torpedo factory (photo courtesy of Ivan Marović)*



■ *Figure 4 Front view of Torpedo Launch Pad Station (photo courtesy of Ivan Marović)*

Smokvina papers, especially the one (Smokvina, 2006) presented on TICCIH Congress 2006, gives chronological overview of Torpedo factory in Rijeka where he mentioned that first torpedo testing in the sea was done in front of the factory on December 20th 1866.

The first torpedo launching station in Rijeka was built before 1880 and second at the beginning of 1900 (Smokvina, 2006). Launch pad station was mandatory facility in the development and production of torpedoes, because every produced torpedo had to pass very difficult testing processes. In order to safely and precisely launch torpedo below, from or above sea level, it was necessary to build such facility which enabled simulation of all launch positions. Those stations were upgraded and used for some time, but none of them remained to present day.

Torpedo launch pad station in Rijeka, in shape as we know it today, enabled simulation of all mentioned torpedo launch positions (Figures 3 and 4), and was constructed in two phases. First phase started at 1929 when the eastern part of the facility was built, and the second one constructed in the period from 1936 till 1945 when the western part of the facility was built.

Building of launch pad station was made of reinforced concrete, steel, stone, wood and glass. Whole bearing structure was made of reinforced concrete and steel, while wall fillings and façade walls were made of stone blocks and hollow bricks with vertical cavities in combination with glass. Roof structure was made of wood. On the south side of the roof structure, wooden observation post was constructed, and was enhanced in relation to remaining roof structure. Facility was founded in very specific conditions; partly on shore and partly on piles and piers in the sea. Most part of the facility, around three quarters, lies just above the sea level where the average depth is ten meters.

Facility stayed in use until 1966, when factory sold torpedo construction rights to other factories around the world and discontinued its military program. After the military program was discontinued, the Launch Pad Station remained unused while for several more decades, Factory stayed in business, producing several different types of air-cooled diesel engines and vehicles, till it finally bankrupt in 2000s. Since then, facility was on vandalism radar.

In more than 150 years of Factory life, name was changed several times; from “Metal foundry” to “Stabilimento Tecnico di Fiume”, “Torpedo Fabric von Robert Whitehead”, “Whitehead & Co.” and finally “Torpedo Engine Factory”.

By the end of 2003, the society for promotion and protection of Rijeka’s industrial heritage, Pro Torpedo Rijeka, was formed. Over the years their mission for bringing forgotten industrial facilities to the spotlight has grow. Their efforts and suggestions of Torpedo Launch Pad Station reconstruction resulted with resolution by Ministry of Culture of the Republic of Croatia in June 2008, concluding that the Torpedo Launch Pad Station and adjacent compressor station for

torpedo air injection, both as part of ex “Torpedo” factory in Rijeka, have attribute of cultural good and have to be renewed.

Present state and comparison

Today, these facilities are rather devastated. Despite years of neglect, according to conducted condition surveys and test results, it appears that both facilities could be repaired. In this heading the condition overview of both facilities will be presented.

In the fall of 2009, SGH performed field investigation of the Miami Marine Stadium structure with ground-penetrating radar testing (in order to measure the concrete cover over reinforcement), which was followed by laboratory work over extracted concrete cores (in order to measure chloride content and petrographic examinations). For each of the five major structural systems, the SGH team (Brainerd, Tumialan and Bronski, 2011) selected at least one area as representative of the typical condition and one representative of the worst condition.

The stadium, essentially a marine structure, has four exposure conditions (Brainerd, Tumialan and Bronski, 2011):

- Submerged zone: the portions of the piles below the mean low-water level. These zones are constantly submerged, so corrosion is limited by lack of oxygen;
- Tidal zone: the pile regions between the mean low- and high-water levels. Members are exposed to alternate wetting and drying, so oxygen, water, and chlorides promote corrosion;
- Splash zone: the portions of the piles above the mean high-water level, the seawall, and other structural elements below the lower seating. Members are exposed to cycles of wetting and drying, so chloride concentrations develop within the concrete and an abundance of oxygen and water promote severe corrosion; and
- Open zone: the upper and lower seating structure, ground and mezzanine slabs, ramps, inclined columns, and roof structure. Members are exposed to seawater mist and rain, but conditions are less severe than in the splash zone.

During facility survey in 2009, submerged zone was not observed, but SGH gave recommendation that it has to be done by additional study. The observed concrete elements show degrees of deterioration ranging from moderate to severe, with the most severe deterioration in the tidal and splash zones, while the structural elements in the open zone show moderate deterioration which doesn't appear to have increased dramatically since 1993 (see Table 1).

Table 1 Comparison of chloride concentrations in 1993 and 2009 (authors redesign according to Brainerd Tumialan and Bronski, 2011)

Sample	Location	Depth from surface [mm]	Chlorides, % by mass of concrete	
			1993	2009
Roof No. 1	Top	6,35	0,022	0,079
	Middle	38,1	0,010	0,035
	Bottom	76,2	0,052	0,040
Roof No. 2	Top	6,35	0,022	0,043
	Middle	38,1	0,013	0,031
	Bottom	76,2	0,043	0,060

As the stadium has been exposed to a tropical climate and marine environment for 45 years the present deterioration appears to be the result of the warm, moist climate and the high chloride contents in the concrete, not carbonation or low-quality concrete (Brainerd, Tumialan and Bronski, 2011).

During 2005 and especially in the period from 2007 till 2009, while the project “Exploration of the Civil Engineering Heritage of Rijeka and its Surroundings” sponsored by the University of Rijeka was active, the detail analysis of concrete structure was conducted. Investigation of Rijeka Torpedo Launch Pad Station was only one part of the project in which the Faculty of Civil Engineering of the University of Rijeka has joined the initiative to protect such facility from further decay in order to redefine and repair its function in the light of its historical role and significance. The project goal (part) was to produce a report in which the current state of structure would be evaluated firstly in terms of structural safety and the level of overall damage, and secondly the viability of facility repair in order to protect and extend its life-span as a protected object of cultural heritage. Project resulted with several papers like Bjelanović et al. (2007), Buha, Car-Pušić and Marović (2009), Grandić et al. (2008), Grgorić (2009), Kovačević et al. (2007), Marović, Završki and Car-Pušić (2009a; 2009b), and others. Mentioned University project was based on facility documentation, former investigations and reports of Institut IGH d.d. – PC Rijeka (Ribarić, 2005), as well as friends from Pro Torpedo.

Torpedo Launch Pad Station can be, as the Miami Marine Stadium, described through similar exposure conditions:

- Submerged zone: foundations and the portions of the piles and piers below the mean low-water level. These zones are constantly submerged, so corrosion is limited by lack of oxygen. Lot of foundations are water-worn and some of piles and piers contain pits and cavities;
- Tidal zone: the pile and pier regions between the mean low- and high-water levels. Members are exposed to alternate wetting and drying, so oxygen, water, and chlorides promote corrosion;

- Splash zone: the portions of the piles and piers above the mean high-water level, the seawall, and working platforms. Members are exposed to cycles of wetting and drying, so chloride concentrations develop within the concrete and an abundance of oxygen and water promote severe corrosion; and
- Open zone: the whole facility. Members are exposed to seawater mist and rain, but conditions are less severe than in the splash zone with exception during south and south-east winds (combination of wind, rain, waves).

Engineering methodology of estimating the current condition of structure was used, which included studying the existing documentation, visual inspection of the structure, field and laboratory testing on specimens taken from structure, preliminary classification of damage and calculation of residual bearing capacity (Bjelanović et al., 2007; Grandić et al., 2008). The goal of laboratory testing was to define the condition of structure materials, which included material properties of the concrete and the corroded reinforcement, permeability of the concrete as well as the amount of chloride ions in the concrete, in order to estimate influence of its age and the effect of aggressive maritime environment to general durability of the facility (Marović, Završki and Car-Pušić, 2009b).

Percentage amount of chlorides by mass of concrete is (Ribarić, 2005) in range from 1.01% to 0.17% depending of type and position of structural element. Same report concluded that the rehabilitation will be expensive according to chloride concentrations and the genuine condition of facility is non-retrievable.

University investigation gave an overview of reconstruction work by structural elements (columns, beams and slabs) in order to rehabilitate the facility. Around 63% of overall structural elements can be repaired and 37% must be substituted (Grandić et al., 2008). Such report presented a base for cost calculations; where Buha, Car-Pušić and Marović (2009) calculated the cost of substitution elements around \$250 thousands and further the cost of all works (Grgorinić, 2009) around \$1.25 million.

Both facilities were estimated as reusable and the required remedial work to rehabilitate the facilities concrete structures will generally fall into two categories:

- Concrete repairs, which are necessary to repair or replace the existing damaged concrete elements to ensure that the structure is safe and serviceable; and
- Corrosion mitigation measures, which are necessary to slow the future rate of deterioration under environmental influences (especially sea influences) and maximize the useful life of the rehabilitated structures.

According to paper (Brainerd, Tumialan and Bronski, 2011), the repair and rehabilitation of facility for safe public use is technically feasible and practical, and the overall cost to repair and protect the Miami Marine Stadium concrete structure alone (excluding architectural improvements such as new railings, improved accessibility, and new concession booths) would range from \$5.5 – \$8.5 million, depending on the type of corrosion mitigation measures.

The overall cost to repair and protect the Rijeka Torpedo Launch Pad Station concrete structure alone would range from \$1 – \$2.5 million, depending on the type of corrosion mitigation measures as well as technology which will be applied during facility repair process.

CONCLUSION

From brief overview and comparison of these facilities, which were not used for several decades, one can conclude that despite their neglect and aggressive surroundings there is still enough time to repair, protect and rehabilitate facilities' structure for the future.

For the citizens of Miami, the Miami Marine Stadium represents the modernity of a growing city and the international cultural influences that helped shape it. The significant architectural and historic characteristics of this modernist icon should not be forgotten. The future of reused Miami Marine Stadium is clear and feasible, moreover, even profitable.

On the other hand, Torpedo Factory and Launch Pad Station has an immense importance not only in local history as a monument of the golden era of Rijeka's industry and municipal development that resulted out of an extraordinary and highly desirable product, but as part of world's industrial heritage, as well. Although by many factors comparable to Miami Marine Stadium, and its rehabilitation equally feasible, Torpedo Launch Pad Station has one major obstacle that the Stadium will not have to deal with – the nature of the facility itself.

In today's profit oriented, fast paced global society; it is not only a question of whether rehabilitation is possible, but whether it can bring future profits and justify the investment. So, the question we must ask ourselves is: "Have we put a price on history?"

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SAŽETAK

Ključne riječi: Pomorski stadion, Lansirna stanica za torpeda u Rijeci, usporedba, industrijsko naslijeđe, prenamjena

U posljednjih stotinu i više godina industrijskog razvoja različite su proizvodne grane smještane uz gradske obale, stvarajući današnje masivne i sive vizure. Neke obale drže korak s izazovima i mijenama suvremenog svijeta, dok se druge jednostavno zapustilo i zaboravilo. Ovaj rad prikazuje dvije pomorske građevine sličnih konstrukcijskih elemenata, no različitih namjena: Pomorski stadion u Miamiu i riječku Lansirnu stanicu za torpeda. Stadion je namjenski izgrađen sredinom šezdesetih, a arhitektonska mu je vrijednost priznata. Bio je projektiran i izgrađen za industriju zabave. Lansirna je stanica rezultat modernog pristupa industrijskim istraživanjima i razvoju tijekom tridesetih i četrdesetih godina. Lansirna stanica za torpeda vrhunac je istraživanja i razvoja industrije torpeda, koja je nastala u Rijeci, a naglasak je bio na funkcionalnosti više nego na estetici. Posljednjih nekoliko desetljeća obje su građevine zapuštene i ostavljene na milost i nemilost vremena i prirode. Unatoč razlikama u vremenu nastanka i razlozima njihova zapuštanja, te se građevine mogu usporediti. Ovaj će prilog ponuditi takvu usporedbu, a izložiti će i građevinski aspekt zaštite i prenamjene. Te su građevine jedinstvene i važno su industrijsko naslijeđe grada Miamijsa i Rijeke, pa ih valja sačuvati za buduće naraštaje.