DEVELOPMENTS OF STEEL STRUCTURES IN ALBANIA

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1. ABSTRACT

A selected history of the developments of steel structures in Albania, in four main periods, in the arch of time from the beginning of the 20th century until nowadays, is presented. Remarkable steel structures in Albania, as the earliest structures, the largest structures, some interesting structures in the design and construction of the past and the presence, are selected and presented. The Bahçallek Bridge as the oldest steel bridge, the Dragot Bridge with the largest span of 108 m, the original solutions used during the Reconstruction after the World War II, the roof space truss of the Palace of Congresses in Tirana with the largest span of 54 m, and, the New Passenger Terminal of the Tirana International Airport "Mother Teresa" as an important building of modern steel structures in Albania, are some from the remarkable steel structures of Albania selected and presented here. A relatively rich history of the developments of steel structures in Albania is presented, as an integral part of the history of such developments in all the region, too. Related to steel structures in Albania, the developments in education and research in the Civil Engineering Faculty of the Polytechnic University of Tirana, as well as, those in the structural steel design codes, are presented here, too.

2. INTRODUCTION

The history of the developments of civil engineering works in a certain country doesn't belong only to the country where these works are built, but, in the same time, it is also an integral part of the history of such developments in all the region. In particular, this is true for steel structures, too.

Albania has its own relatively rich history of the developments of steel structures, beginning early in the 20th century. This history is presented here in four main periods: from the beginning of the 20th century up to the year 1944 and to the end of the World War II, after the year 1944 with the Reconstruction of the country, then with the centralized socialist economy, and at last, after the year 1990 with democratic changes in the country. Some of the remarkable steel structures in Albania, such as, the earliest structures, the largest structures, some interesting structures in the design and construction of the past and the presence, are selected and presented here as milestones in the way of the history of steel structures in Albania.

Related to the developments of steel structures in Albania, the education and research in the Civil Engineering Faculty of the Polytechnic University of Tirana, as well as, the structural steel design codes, are discussed here, too.

3. A SELECTED HISTORY OF STEEL STRUCTURES

3.1 From the beginning of the 20th century up to 1944

Four remarkable steel bridges are selected for this period: the Bahçallek Bridge, Buna Bridge, Lekli Bridge and the Dragot Bridge.

The steel ***Bahçallek Bridge*** over the Drin River in the city of Shkodra is the oldest steel bridge in Albania. It was built before the year 1912, the year of the Independence of Albania and the year of the establishment of the independent Albanian State [1][2].

The Bahçallek Bridge has been a very important work-of-art of the road Tirana - Shkodra at the 97th kilometre [2], linking the cities of Shkodra and Lezha. Next to this steel bridge, since 1972 and then, a new reinforced concrete bridge has been designed and constructed by Albanian engineers [2] (Fig. 1 – left). Today, the steel Bahçallek Bridge, not any more in service (Fig. 1 – right), is under the attention of the Institute of Culture Monuments in Tirana [3].

Fig. 1 The Bahçallek Bridge
Left – View from the Rozafa castle: steel bridge (down) and reinforced concrete bridge (up);
Right – View of the steel bridge from the side of Shkodra

The original steel Bahçallek Bridge has a total length of 144.5 m, with 5 large spans and 1 lateral small span on the side of Shkodra, as well as, it is a single-lane bridge with a usable width of 4.0 m. The main structural elements of each of the 5 large spans are two simply-supported steel trusses (Fig. 2), with a span at the maximum of L=27 m, with a depth of H=2.53 m, and realized with rivet connections and splices. The original steel Bahçallek Bridge has had two main interventions (replacement of the original trusses in the two lateral large spans on the side of Shkodra (Fig. 1 – right)) [4], in the year 1945 after the damages of the World War II, and in the year 1952 for the bridge reinforcement needs.

Fig. 2 The steel Bahçallek Bridge – original trusses

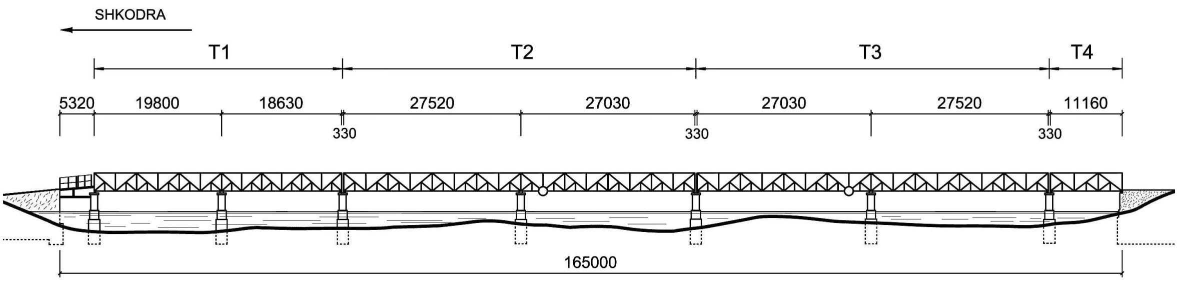
The ***Buna Bridge*** over the Buna River in the city of Shkodra is another old steel bridge in Albania. This steel bridge, actually in service (Fig. 3), is a vital link of Shkodra with its surroundings and Montenegro.

Fig. 3 The Buna Bridge today
Left – View from the side of Shkodra; Right – Entering towards Shkodra

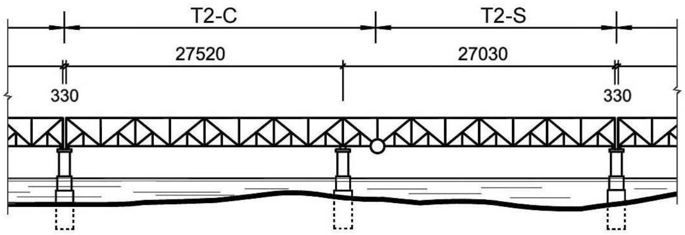
The steel Buna Bridge, with its first design project of the year 1911 and 1912 (Austrian project) [5], results as the bridge with the oldest design project in the archival fund of the transport infrastructure works in the Central Technical Archive of Construction in Albania [2]. In the year 1927, the steel Buna Bridge, having passed through the World War I and further, results with its superstructure consisted of only a part of its original steel superstructure as well as of a temporarily reconstructed part [6]. The design project of the year 1927 (Austrian project) of the Buna Bridge [5] had just to replace the temporarily constructed part with a definitive one, as in its original steel superstructure [6]. The Buna Bridge, with its steel superstructure as in its original (Fig. 4), was completed in 1928 [7]. Today the original steel superstructure of the Buna Bridge results as totally replaced by another steel superstructure of the Bailey type (Fig. 3), in the beginning because of the damages of the World War II, and later on, time after time, for the bridge reinforcement needs [5].

The steel Buna Bridge is also the only bridge in Albania that has functioned as a movable bridge, allowing the movement of ships along the navigable Buna River, and, so, linking the Adriatic Sea with the Shkodra Lake. Both of the design projects of the Buna Bridge, the first design project of the year 1911 and 1912 and the design project of the year 1927, had foreseen the solution of a movable bridge allowing the navigation [2] [5] [6]. The report about the test done at the end of works of the Buna Bridge, in 1928, confirms that the bridge opening-closing process functioned quite well, the bridge opening took 10 minutes and the closing 12 minutes [7].

The Buna Bridge has a total length of 165 m, with 6 large spans and 2 small lateral ones. It is a single-lane bridge, with a useable width of 4.0 m for its original superstructure and of 3.2 m for the actual Bailey one. Regarding the original Buna Bridge (Fig. 4-a), the main structure of the 6 large spans consists of two riveted steel trusses, with a distance of 4.2 m, with a span at the maximum of L=27.52 m and with a depth of 2.8 m. Continuous trusses were used for the two large spans from the side of Shkodra and cantilever (Gerber) trusses for each of the two spans in the other large spans (Fig. 4-a). In each of these two spans with cantilever (Gerber) truss (Fig. 4-b), it was the suspended truss that during the World War II has been collapsed and then replaced, firstly with a wooden structure, and then, with a Bailey one.



(a)



(b)

Fig. 4 The original Buna Bridge
(a) **–** *Bridge elevation***:** *T1 – continuous truss; T2 & T3 – cantilever (Gerber) truss; T4 – simply supported truss; (b)* **–** *Fragment of two spans with cantilever (Gerber) truss***:** *T2-C – cantilever truss; T2-S – suspended truss.*

The steel ***Lekli Bridge***, over the Drino River (branch of the Vjosa River) and near the southern city of Tepelena, is a work-of-art in the road Tepelena – Kelcyra, just after this road branches from the road Tirana – Tepelena – Gjirokastra. The Lekli Bridge is the oldest steel bridge in Albania that is in service today with its original superstructure, without any change during its life. The design project of the Lekli Bridge (a French project) is of the year 1925 and 1926 [8].

The Lekli Bridge is a two-span bridge with a total length of 81 m, as well as, a single-lane bridge with a usable width of 4.0 m. The main structural elements of each span are two simply-supported steel trusses (Fig. 5), with a distance of 4.5 m, with a span of L=40.0 m, with a depth of 4.5 m, and as riveted trusses.

Fig. 5 The Lekli Bridge

The steel ***Dragot Bridge***, over the Vjosa River, is another work-of-art in the road Tepelena – Kelcyra, following the Lekli Bridge in the way towards the city of Kelcyra. The steel Dragot Bridge is the largest span bridge in Albania with the span of 108 m. It is also as another old steel bridge in Albania that is in service today with its original superstructure. Its design project (Italian project) is of the year 1935 [9].

The Dragot Bridge is a single-span bridge and a single-lane bridge, with a total width of 7.86 m, accommodating a usable road width of 4.7 m and two sidewalks of 1.0 m outside the bridge structure. The main structural elements are two riveted steel trusses of a polygonal layout (Fig. 6), with a distance of 5.43 m, with a span of L=108 m and with a depth of 12.0 m at the mid span.

Fig. 6 The Dragot Bridge – view towards Tepelena

The trusses are braced at the top and bottom chords, as well as, vertically (Fig. 7). The vertical bracing, at the main vertical members of the truss lattice, is placed 4.82 m over the bridge pavement.

Fig. 7 The Truss Bracing of the Dragot Bridge
Left – Fragment of the braced trusses; Right – Bottom view towards Tepelena

3.2 Reconstruction process after the World War II

One of the most urgent objectives of the Reconstruction process in Albania, after the World War II, was the rehabilitation of the paralyzed road network, with 4500 linear meters of damaged and collapsed bridges [1]. The structural steel, with the merit of the fast erection, was widely used in this reconstruction process, not only for steel bridges but and for reinforced concrete ones. Related with the other merit of reusing structural steel products and elements, after repairing and adapting, the petroleum steel tubes, hangar steel trusses, and steel trusses of the Herbert type, all available in the country, were used in the reconstruction process of bridges. On the other hand, steel trusses of the Bailey type, provided by UNRRA (United Nations Relief and Rehabilitation Administration), were widely used in this reconstruction process of bridges, too. All this reconstruction process of bridges, including relevant studies, design and construction, was faced from the Albanian engineers of that time [1] [2], educated in the Western European Universities.

An interesting ***bridge example with petroleum steel tubes*** is the ***Rrogozhina Bridge*** over the Shkumbin River, at the 40th kilometre of the road Durres – Vlora [2] and where the cities of Rrogozhina and Lushnja meet each other. The Rrogozhina Bridge with petroleum steel tubes was built in 1945 (Fig. 8 – left), near and instead of the previous Rrogozhina Bridge with 5 reinforced concrete arches of a span of L=47.2 m, collapsed during the World War II. The Rrogozhina Bridge with petroleum steel tubes, recently not any more in service (Fig. 8 – right), has to be under the attention of the Institute of Culture Monuments in Tirana for its original solution.

The Rrogozhina Bridge with petroleum steel tubes has a total length of 216 m, consisted of two parts, the part of the petroleum steel tubes superstructure with a length of 144 m and 9 spans of L=16 m, and the other part of the reinforced concrete superstructure with a length of 72 m and 9 spans of L=8 m. The bridge is a single-lane bridge with a total width of 4.4 m, accommodating a usable road width of 3.0 m and two sidewalks of 0.55 m. The main structure of the steel tubes superstructure [1] [10] consists of two groups of structures of an axial distance of 1.8 m, while, each of the two groups, with the cross-section width of 1.034 m, consists of three trussed-beams, of a slung framing type and of an axial distance of 0.395 m from each other. Each of the trussed beams is a continuous structure with a span of L=16 m and a depth of H=1.72 m (as an axial distance). The top chord of the trussed beam is built up from two petroleum steel tubes of a diameter of D=24.5 cm, placed one over the other with a space of 6.0 cm (by means of proper spacers). A continuous top chord is provided by welded plated splices of the 8.0 m long petroleum steel tubes. To work together and provide a built-up section, the two tubes of the top chord are enclosed and plated braced, spaced at 1.2 m to 1.9 m along the chord. A 10 cm deep double channel section is used for the horizontal bottom chord, and, a 12 cm deep I section is used for both, the incline bottom chord and the incline strut of the trussed beam. The top chords of all the six trussed beams, of the two groups together, are braced together transversally with vertical steel bracing, as well as, they are partially encased in the reinforced concrete slab of the bridge deck.

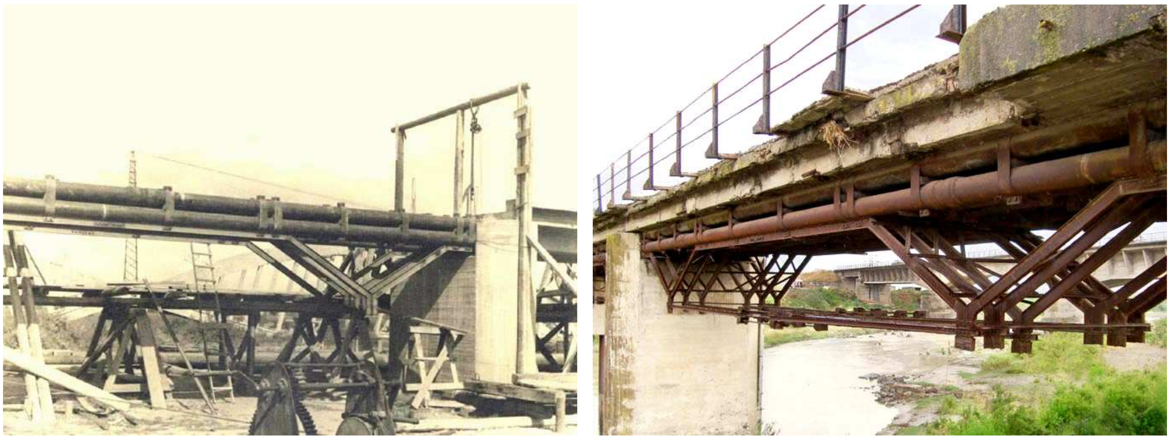


Fig. 8 The Rrogozhina Bridge with petroleum steel tubes
Left – During construction in 1945; Right – The bridge today

The ***hangar steel trusses*** (of a depth of H=4.0 m), by reinforcing and adding new intermediate supports, were used as continues trusses in bridges. The Mifol Bridge [1] [2], over the Vjosa River and in the road Fier – Vlora, previously with 5 reinforced concrete arches of a span of L=47.2 m and remained after the World War II with only 1 arch, results as the bridge with the longest span of L=23.6 m reconstructed in Albania with hangar steel trusses, as completed after the design of 1945. After the design of 1949, to reinforce the bridge, another intermediate support was added (Fig. 9).

Fig. 9 The Mifol Bridge

The existing ***steel Herbert trusses*** (of a depth of H=2.0 m), as standard military bridge trusses consisted of pre-fabricated modular units of a pyramidal form (pyramidal unit of 2 m deep and of a rectangular base of 1.2 m across and 2.5 m along the bridge), after repairing their damages of the World War II, were used in the reconstruction process of bridges, too (Fig. 10). The Topojan Bridge [1] [2], a single-span bridge over the Black Drin River and in the road Burrel – Peshkopi, previously with a reinforced concrete arch of a span of L=36.2 m and then collapsed during the World War II, results as the bridge with the longest span of L=27.5 m reconstructed in Albania with steel Herbert trusses, as completed after the design of 1946. These steel Herbert trusses of L=27.5 m were suspended to the reinforced concrete cantilevers of 5.3 m long at both of the bridge supports. The Topojan Bridge, after the design of 1974, was reconstructed again as a reinforced concrete arch bridge.

Fig. 10 Herbert trusses during Reconstruction
Left – The Bahçallek Bridge; Right – The Mat Bridge

The ***steel Bailey bridge trusses***, developed for use by the Allied armies in the World War II after the design of Donald Bailey (British), were widely used in the reconstruction process of bridges in Albania (Fig. 10). The Bailey bridge trusses [11], easily adjusted to accommodate different span lengths and traffic loads, consist of pre-fabricated modular units of 1.45 m deep and 3.05 m long, light enough to be manhandled. The Bailey bridge trusses, on each side of the bridge, can be up to three units wide and two units deep. The Bailey bridge trusses are firstly described of how much units the truss is wide, and then, how much units deep. For example, the description Double-Single (Fig. 11) means the truss is two units wide and a single unit deep.

Fig. 11 Double-Single Bailey bridge trusses – The Buna Bridge
Left – Side view; Right – Top view

The Doda Bridge [1] [2], over the Black Drin River and in the road Peshkopi – Kukes, results as the bridge with the longest span of the Double-Double Bailey bridge trusses used in Albania, with the span of L=48.77 m, as firstly constructed after the design of 1946, and then with the span of L=42.67 m, as reconstructed after the design of 1949. The Shijak Bridge, over the Erzen River and in the road Tirana – Durres, results as the bridge with the longest span of L=36.6 m reconstructed in Albania with Triple-Single Bailey bridge trusses, as completed after the design of 1954 [1] [2]. The Shijak Bridge was built after the design of 1923 as a two-span bridge with steel parabolic trusses of a span L=35.0 m, was collapsed during the World War II, was firstly reconstructed in 1945 as a suspended pedestrian bridge, then, after the design of 1954 was reconstructed as a two-span Bailey bridge, and at last, after the design of 1974 was reconstructed as a reinforced concrete arch bridge [1] [2].

3.3 Through the period of the centralized socialist economy

The mostly used steel structures in Albania, during the period of the centralized socialist economy, are those in ***industrial buildings and works***. A multi-branched industry was developed during this period. The industry during this period benefited and from the established eastern-oriented relations of Albania with the Soviet Union (1948–61) and China (1961–78), in financial and technical aids. One of the largest industrial enterprises of Albania in this period is the Metallurgical Combine near the city of Elbasan, occupying an area larger than the city of Elbasan in itself. The construction of the Metallurgical Combine began in 1971 and passed through some phases. As resulted in 1985 [12], 41.000 tons of steel structures were produced and used for the construction of different industrial buildings and works of this Metallurgical Combine. Two remarkable steel structures are selected here from the Metallurgical Combine in Elbasan, a special steel-girder of a span of L=36 m in the Steel Plant [13], both serving as a crane runway girder and a substantial roof girder, as well as, a gas-holder of a 54.000 m^3 capacity [14].

The ***Steel Plant of the Metallurgical Combine in Elbasan*** is a single storey building, 120.5 m wide and 206.5 m long, with 5 spans varying from L=21 m, L=24 m up to L=27 m, and, with a total of 25 overhead traveling cranes with a lifting capacity varying from 12 tons, 15/3 tons, 20/5 tons, 50/10 tons up to 75/20 tons. From all the steel structures of the building, such as roof trusses, the steel upper part of the columns (over the crane runway), different crane runway girders, etc. (Fig. 12 – left), a special steel-girder is selected in the 36 m long column-free segment (imposed by the technology needs) of the lateral longitudinal axis of the building (Fig. 12 – right). This ***special steel-girder with its span of L=36 m***, like a built-up box girder, serves both as a crane runway girder and a substantial roof girder. The loads of four overhead traveling cranes with their lifting capacity of 12 tons and 15/3 tons and with the crane-length of 22 m, as well as, the loads from the roof trusses with the span of 24 m, are all to be accommodated from this girder. This special steel-girder, like a built-up box girder, consists of two parallel built-up steel girders (in a distance of 1.65 m) braced together at the levels of top and bottom flanges, and, vertically braced at a space of 6 m, too. While the crane runway is situated over the inside girder, the two parallel girders share their roof truss loads as 21.2 % for the inside girder and 78.8 % for that outside. Both these two parallel built-up steel girders, of the span of L=36 m, result with their depth of 3.35 m, while, on the other hand, they differ in the flanges dimensions and in the web thickness, having a flange section of 620x25 mm and 550x22 mm and a web thickness of 16 mm and 14 mm, for the inside girder and the outside girder, respectively. The two parallel built-up steel girders result also as welded built-up girders with transverse and longitudinal stiffening ribs, as well as, with riveted splices and riveted bracing connections.

Fig. 12 Metallurgical Combine in Elbasan – The Steel Plant during construction
Left – Fragment of the Steel Plant; Right – A special steel-girder of a span of L=36 m

A ***variable-volume gas-holder of a capacity at the maximum of 54.000 m³*** [14], built in the Metallurgical Combine in Elbasan, is selected here, too. As a variable-volume gas-holder, it was designed for a low pressure not exceeding 3.53 kPa (0.035 atm). On the other hand, as a variable-volume gas-holder, it was designed and constructed as the type of a wet gas-holder with helical guides (of a telescopic form) (Fig. 13).

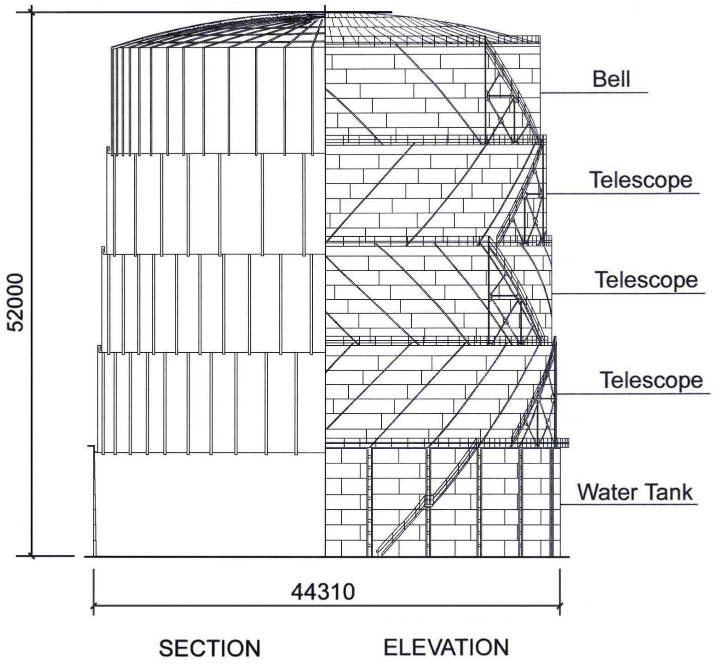


Fig. 13 Wet gas-holder with helical guides of a 54.000 m³ capacity – built in Metallurgical Combine in Elbasan

The gas-holder of this type built in the Metallurgical Combine in Elbasan, with a maximum diameter of 44.31 m and a maximum height of 52 m, was designed and constructed of 5 units: the bell as the upper movable unit, the 3 telescopes as the intermediate movable units, and the tank as the lower fixed unit, filled with water (Fig. 13). Under the influence of the gas pressure, a rising helical movement of the gas-holder of this type begins with the bell, carrying along the upper telescope, and then, in turn, it continues with the telescopes. The helical movement of the bell and the 3 telescopes is due to the presence of the helical guides at an angle of 45 º on the outer surface of the bell and the telescopes (Fig. 13), and also, of the relevant couples of rollers on the upper end of the telescopes and of the tank. The gas-holder gets its maximum capacity and its maximum height when all the movable units, the bell and the telescopes, are in their upper position (Fig. 13). On the other hand, the gas-holder gets its lower position and its minimum height when all the movable units, the bell and the telescopes, are in their lower position inside the tank and rest on special seats on the tank bottom. Hydraulic seals are provided between different units of the gas-holder, not allowing the gas escape.

The steel structures, during the period of the centralized socialist economy in Albania, in addition to the industrial buildings and works, were used for ***social and cultural buildings***, too. The steel space truss of the roof of the Palace of Congresses in Tirana is selected here as a remarkable structure for these kinds of buildings in Albania.

The ***roof steel space truss of the Palace of Congresses in Tirana***, with its design of 1984 [15], is the largest span roof in Albania with a span of 54 m. It is a double-layer flat space truss of a circular plan layout, with a diameter of D=54 m, a depth of 5.35 m at the center and 2.00 m at the supports (Fig. 14).

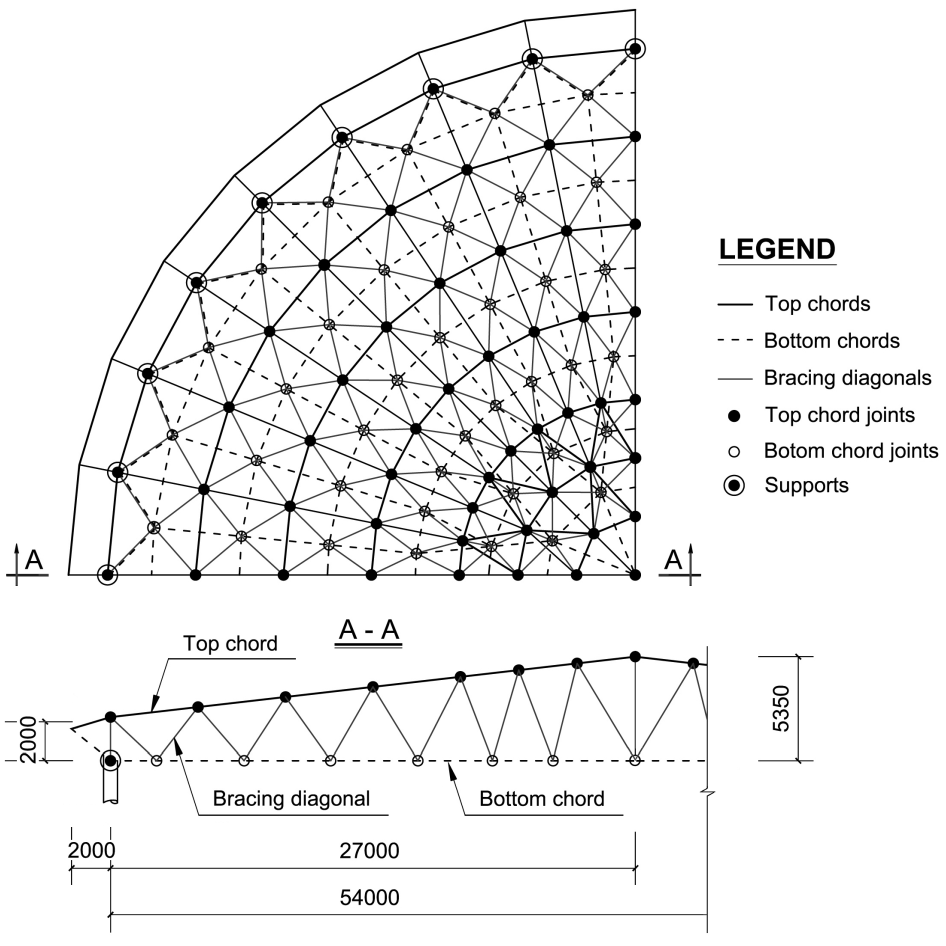


Fig. 14 The grid arrangement of the roof steel space truss of the Palace of Congresses in Tirana

Square hollow sections, as built-up of two equal-leg sections continuously welded along their edges, were used for the members of the steel space truss. On the other hand, circular shaped tubes, as seamless tubes, of a length of 40 cm, a diameter of 18.0 cm and 16.8 cm, and a thickness of 3.5 cm, were used for the nodes of the steel space truss [15] [16]. Plate connectors and welded connections were used for the member-node connections of the steel space truss. The plate connector had to be welded along the circular shaped tube of the node, and, on the other hand, while the end of the truss member was slotted for an adequate length, the plate connector had to be inserted in the slot and welded, too. The space truss members and nodes were produced in the Metallurgical Combine in Elbasan [16]. A temporary steel structure, especially designed, was used for the erection of the steel space truss. The central part of the steel space truss, of a radius of 11.25 m, was assembled directly in its final position over a special platform supported by the temporary steel structure. On the other hand, 16 radial sub-assemblies were pre-assembled on the ground and then lifted into their final position, supported by the definitive outer ring of reinforced concrete and of a radius of 27 m, and, by the inner ring of a radius of 11.25 m, as part of the temporary steel structure (Fig. 15 – left). Each of the 16 sub-assemblies, of a weight of 4.5 tons, was a part of the truss circular plan layout as a 1/32 part of the circle between the radii of 11.25 m and 27 m. For the rest of the truss members, they were separately lifted and then assembled. After assembling the entire space truss (Fig. 15 – right), a well-defined scheme was used for the launching of the whole space truss into its working position [15] [16].

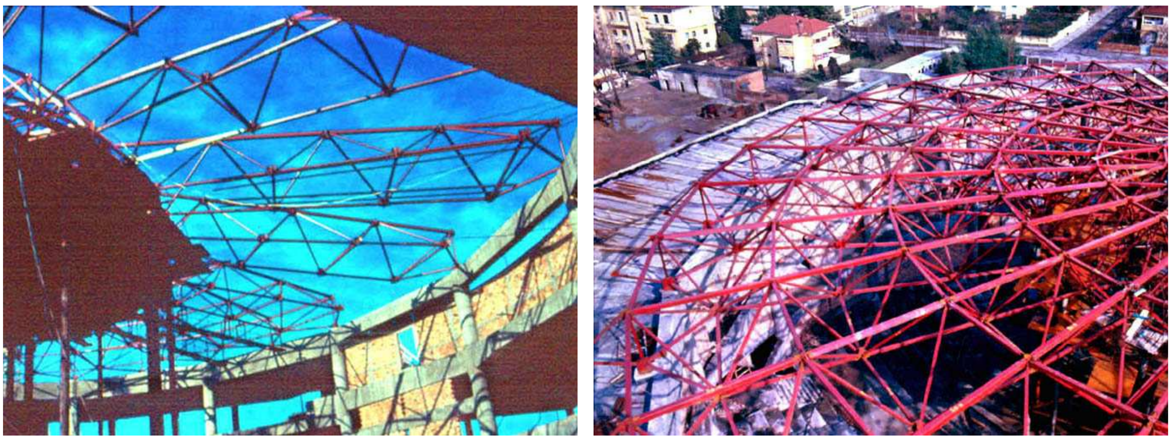


Fig. 15 The roof steel space truss of the Palace of Congresses during construction
Left – Truss radial sub-assemblies; Right – Fragment of the entire assembled space truss

All the construction process of the roof steel space truss of the Palace of Congresses in Tirana, including relevant studies, structural analysis computer programme, design, and construction, was faced from the Albanian engineers, in collaboration with the University of Tirana and the Center of Applied Mathematics and Computer Science (INIMA) in Tirana [16].

3.4 After 1990 with democratic changes

Actually, referring to this period after the year 1990 with democratic changes in the country, a significant development of steel structures results in Albania. Different steel structures result to be constructed during this period, such as industrial buildings and works, commercial buildings, social buildings, bridges and overpasses, petrol stations, power transmission line towers, etc. Albanian companies result to operate successfully in the design and construction of steel structures in Albania, either totally engaged with steel structures (*Konstruksione Metalike Shpk* (Ltd.) in Tirana; *Sigma Shpk*. (Ltd.) in Tirana; *Europa Shpk*. (Ltd.) in Elbasan, etc.), or, both engaged with steel structures and reinforced concrete structures, too (*Trema Engineering 2 Shpk* (Ltd.); etc.). Partnerships with international companies or international companies in their own operate successfully, too. Two remarkable steel structures are selected here: The New Mat Bridge and the New Passenger Terminal of the Tirana International Airport “Mother Teresa”.

The ***New Mat Bridge*** (Fig. 16), built in the year 2002 over the Mat River and near the city of Milot, is an important work-of-art in the road Tirana – Shkodra. The New Mat Bridge is the first composite steel concrete bridge built in Albania, as well as, it is the second longest bridge in Albania and the longest steel bridge.

The New Mat Bridge [17] has a total length of 620 m, with 18 spans and with the spans distribution as 30 + 16 x 35 + 30 m, as well as it is a three lane bridge with a total width of 12.5 m, accommodating a usable road width of 10.5 m and two sidewalks of 1.0 m. The main structural elements are two continuous beams, as steel girders acting compositely with the reinforced concrete slab. The two main steel girders, spaced at 6.9 m, with a span at the maximum of 35 m, and, of a depth of 1.9 m, are interconnected at 7.5 m intervals by light transverse trussed beams and by transverse girders at the supports. The girders, after their welding and stiffening against local buckling in shop, were transported to the construction site divided into 11 m and 12 m segments, and then, the remaining connections, with high strength bolts, were at the site, under quality control conditions. All the steel part of the bridge was erected by crane. The bridge was designed and constructed by an Italian company.

Fig. 16 The new Mat Bridge – Composite steel and concrete bridge
Left – Side view; Right – Bottom view

The ***New Passenger Terminal of the Tirana International Airport “Mother Teresa***” (previously - the Rinas Airport) [18], opened in March 2007, is an important building of modern steel structures in Albania (Fig. 17). The construction of the New Passenger Terminal was privately managed by Tirana International Airport Shpk. (Ltd.) consortium, which holds the rights to manage, operate and develop the Tirana International Airport “Mother Teresa” for a period of twenty years, under the BOOT (Build, Own, Operate, Transfer) concession agreement signed in October 2004 between the Albanian Government, the former owner, and this consortium. The Tirana International Airport Shpk. (Ltd.) consortium is owned by HOCHTIEF Airport GmbH (HTA), one of the world’s leading private airport managers and investors, DEG – Deutsche Investitions- und Entwicklungsgesellschaft, a member of the KfW Banking Group specialized in the financing of corporate and infrastructure investments in Europe, and the Albanian-American Enterprise Fund (AAEF), founded in 1995 by the United States Congress to support Albania’s transition to a free market. The New Passenger Terminal of the Tirana

International Airport “Mother Teresa”, with an initial annual capacity of one million passengers and enabled to be increased up to three million, was designed by the Malaysian architect Hin Tan, educated in the UK, with a 18 years experience in some of Europe’s leading architectural practices, in London and Paris, and, after the year 2000, returned to Malaysia with national and international projects. The Tirana International Airport “Mother Teresa” is the winner of the PAM Award 2007 in the Overseas Projects Category, awarded by the Malaysian Institute of Architects (PAM). On the other hand, the structural design and construction of the New Passenger Terminal of the Tirana International Airport “Mother Teresa” were undertaken by the Albanian company Trema Engineering 2 Shpk. (Ltd.), as one of the leading companies in structural design and construction in Albania. While, the German company DIWI Consult International GmbH, specialized in planning, design and construction in civil engineering, was charged as the design checker, as well as, as the construction supervisor. The construction began in May 2005 and was completed in March 2007.

Fig. 17 New Passenger Terminal, Tirana International Airport “Mother Teresa”
Left – Truss zone roof; Right – Terminal Entrance.

The New Passenger Terminal [19] is a single storey building of a T-form plan layout, of a total T-depth of 112 m, a T-web-width of 66 m, and a T-flange-width of 138 m. The T-form plan layout consists of the T-flange zone, specified as the Truss zone, and, of the T-web zone, as the Beam zone. The symmetry axis of the T-form plan layout is referred here as the building longitudinal direction. After entering the glazed façade at the landside in the Truss zone and after the check-in, the progress from landside to airside is linear in the longitudinal direction of the building and towards the departure hall at the end of the beam zone, where another glazed façade at the airside reveals the aircraft and runway beyond. The building has a mono pitch roof falling gradually in the longitudinal direction (a slope of 4 º), from the landside towards the apron at the airside. The height of the building varies from 16 m at the landside to 9 m at the airside. All the building structure is a steel-framed structure. All the structural steel members are of European standard sections, such as HE-A and HE-B sections (European wide flange beams), CHS and RHS sections (European Circular and Rectangular hollow sections, respectively), IPE Sections (European I beams), as well as, of welded plated built-up I sections. The connections, mainly, are bolted connections.

The Beam zone, measuring 112 m x 75 m, has a steel-framed structure with moment-resisting joints and mainly pinned supports, except the rigid supports at the ends of the Beam zone, at the end where the Beam zone meets the Truss zone and at the airside end. As part of the longitudinal main frame of the building (in the longitudinal direction of the building) (Fig. 18-a), the steel frame in the Beam zone, spaced at 12 m, consists of five spans from 9 m, 12 m to 18 m, spanned by the continuous main beams of a HE-600-A section. Secondary beams of a HE-300-A section, spaced at 3 m, are supported on the main beams. The transverse steel frame in the Beam zone (Fig. 18–c) consists of 6 spans, 5 spans of 12 m and a shorter lateral one of 6 m. The columns in the Beam zone, mainly, are conventional vertical columns of a CHS-406.4/12.5 section. The columns at the airside end of the Beam zone are architecturally expressed as V-shape columns (a slope of 18 º) (Fig. 18-a; Fig. 19 – right), and, they are of welded plated built-up I sections, being tapered from a section depth of 849 mm at the top to a section depth of 616 mm at the bottom. The columns at the end of the Beam zone, where the Beam zone meets the Truss zone, are inclined columns (a slope of 20 º) of welded plated built-up I sections, being tapered from a section depth of 1010 mm at the top to a section depth of 543 mm at the bottom. These columns, together with the inclined bracing of a CHS-406.4/12.5 section, are also architecturally expressed as overturned V-shape members (Fig. 18-a; Fig. 20 – right).

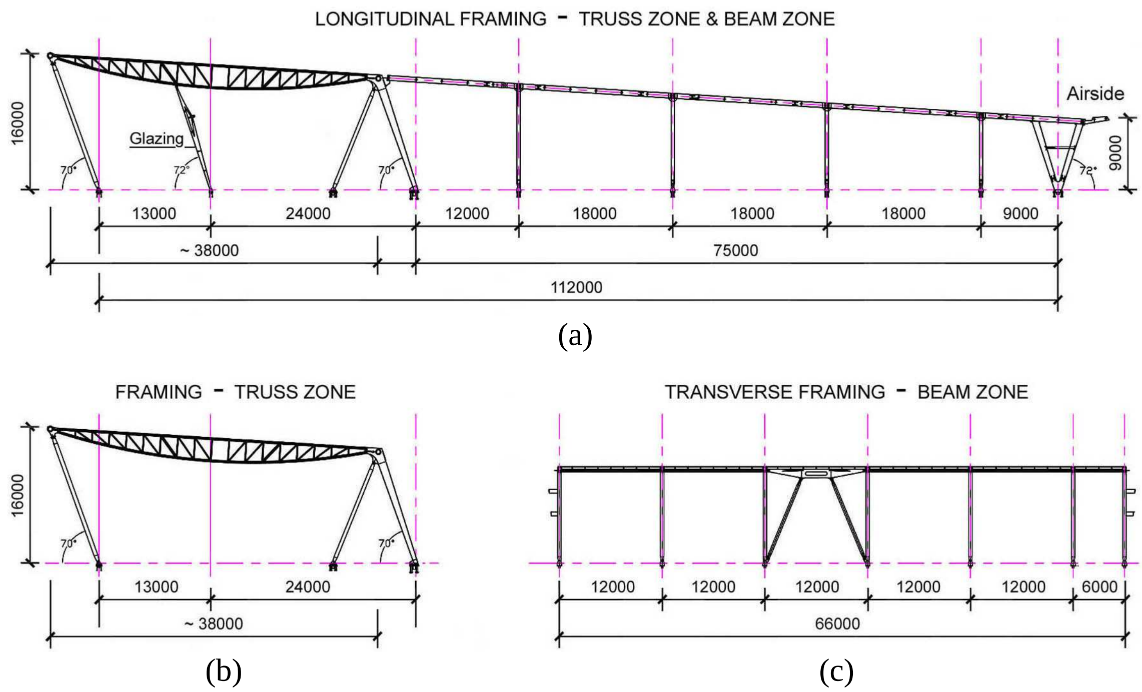


Fig. 18 Structural framing – New Passenger Terminal, Tirana International Airport "Mother Teresa" (a) – Longitudinal structural framing in the Truss and Beam zones, inside the width of the Beam zone; (b) – Structural framing in the Truss zone, outside the width of the Beam zone; (c) – Transverse structural framing in the Beam zone.

The Truss zone, of a 38 m x 132 m area and with a single span of 38 m in the longitudinal direction of the building (as it is referred here), is named after its roof steel trusses of a 6 m spacing and of a 38 m span. The roof trusses are of a bow-string shape, with a straight top chord of a slope of 4 º and a parabolic bottom chord, both of a HE-240-B section, and, with falling diagonals of an IPE-240 section. Purlins of a HE-180-A section and of a 4 m spacing are supported on the top chord of the trusses, as well as, purlins of a RHS-150x100 section and of a 2 m spacing are supported on the bottom chord. The roof trusses, spaced at 6 m, are rigidly supported on each of the two sides, on the columns of a 12 m spacing, as well as, on the beams under the roof trusses, as beams spanning between these columns. The beam under the roof trusses is a continuous beam of a CHS-457/16 section. The trusses are braced at the levels of their top and bottom chords, and, vertically, too. The columns of the entrance side of the Truss zone, of a CHS-457/10 section and pin-supported, are also architecturally expressed as inclined columns with a slope of 20 º (Fig. 17). The other columns on the other side of the truss zone, along the axis where the Truss zone meets the Beam zone, are rigidly-supported and of the same cross-section, inside and outside the width of the Beam zone (Fig. 18-a, b). As it is mentioned above, together with the inclined bracing, these columns are also architecturally expressed as overturned V-shape members. The glazing of the entrance (Fig. 18-a), nearly at the middle of the 32 m span of the truss zone, is supported at its own foundation and at the truss bottom chord, where, due to a sliding support, it is no affected by the truss loads.

Fig. 19 New Passenger Terminal, Tirana International Airport "Mother Teresa" – During construction: Left – Transverse bracing in the Beam zone; Right – V-shape columns along the airside axis at the Beam zone

All the framed-structure of the building, as a whole, is braced at the roof level, in the Truss zone and the Beam zone, as well as, between the columns, in the transverse and longitudinal directions of the building. The joints of the framed structure are architecturally expressed and structurally interesting, too (Fig. 20).

For the framed-structure of the building, as a whole, a 3D static and dynamic analysis was performed by the structural engineers, as well as The British Codes were mainly used for the structural design, except the Eurocode EC-8 for the seismic design. Special joints of the framed-structure were modeled and analysed by means of finite element techniques.

Fig. 20 Exposed joints – New Passenger Terminal, Tirana International Airport "Mother Teresa": Left – along the entrance side axis at the Truss zone; Right – along the axis where the Truss zone meets the Beam zone

4. EDUCATION, RESEARCH AND DESIGN CODES

Up to the year 1990, the teaching of steel structures in the University was after the Eastern experience and, mainly, the Russian one. With democratic changes in the country after the year 1990, the general orientation of the country towards Western European countries was reflected to the high education, too. The Tempus Programme has been very useful for the revision and updating of the curricula in Civil Engineering, according to those of Western European Universities, and, very useful for the retraining of the teaching staff, too. The steel structures, as an integral part of all the courses in Civil Engineering, have benefited from the Tempus JEP Projects (AC JEP 11558-96 with the partnership Paris-Tirana-Turin and AC JEP 13134-98 with the partnership Tirana-Athens-Turin), as well as, from the Tempus IMB Mobilities (Rome, Turin, London), too.

On the other hand, regarding the research in the University, the studies have been oriented to the needs of the real practice of steel structures for technical-economical solutions. One of the directions of such research studies, beginning from the year 1980, was related with steel space trusses and, especially, with double-layer flat space trusses [20]. The studies were related with the structural analysis after the finite element method, structural analysis after the equivalent continuous environment method, temperature changes effect, seismic vertical component effect, member-node joints, as well as, with the composition of the relevant structural analysis computer programmes. Following these studies and up to now, certain steel space roofs have been designed and constructed in the country, culminated with the steel space roof of the Palace of Congresses in Tirana (Fig. 14, 15). Another direction of the research studies is related with the optimum design of steel trusses. Based on the fact of not having a single best optimization method for steel trusses, a package of some optimum design procedures by the most efficient optimization methods has been intended. Such a package, with optimum design procedures solving practical problems and complying with the Albanian Code KTP-10-78 of the steel structures, has been intended, too. The relevant studies resulted with the optimum design procedure after the optimality criterion of the feasible most stressed state and/or the feasible largest slenderness ratio state [21], as well as, they also resulted with the optimum design procedure of steel trusses after an optimization method of nonlinear mathematical programming, such as the optimization method of sequential linear programming with move limits [22] [23]. The relevant computer programmes for the two procedures were composed, too.

University always has had a key role in the development of the structural design codes. Actually, as the country has entered the process of adopting Eurocodes as the national structural design codes, in general and in particular for steel structures, the University has the great challenge, not only for the teaching aspects, but also, as an important actor, in propagating the Eurocodes and preparing the national annexes, too.

5. CONCLUSIONS

The history of the developments of steel structures in Albania, as an integral part of the history of such developments in all the region, results as a relatively rich history, beginning early in the 20th century till nowadays. It is related with different circumstances in the different periods of the country, but it is due to the material of steel in itself, with its wonderful properties used by engineers. The actual developments of steel structures in

Albania promise that the history of steel structures will continue in the way of positive developments.

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