ALUMINIUM ALLOY STRUCTURES: FIELDS OF APPLICATION

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ALUMINIUM STRUCTURES IN THE FIELD OF CIVIL ENGINEERING:

- BUILDINGS
- SPECIAL STRUCTURES
- BRIDGES
- REFURBISHMENT
- ENVELOPS (FACADES)
BUILDINGS:
- prefabricated structures
- plane structures
- reticular space structures
- domes
ALUMINIUM PREFABRICATED STRUCTURES
“Trelement” building system (Germany)

Prefabricated club-house (France)
Prefabricated rural building (Italy)

ALUMINIUM PREFABRICATED STRUCTURES
ALUMINIUM PREFABRICATED STRUCTURES

Prefabricated - aluminium house (Tokyo, 2000)
ALUMINIUM PREFABRICATED STRUCTURES

Provisional Exhibition Hall (Udine, Italy, 2002)
ALUMINIUM PREFABRICATED STRUCTURES

Provisional Exhibition Hall
ALUMINIUM PREFABRICATED STRUCTURES (EDENBLUE SYSTEM)
ALUMINIUM PREFABRICATED STRUCTURES (EDENBLUE SYSTEM)
ALUMINIUM PREFABRICATED STRUCTURES (EDENBLUE SYSTEM)
ALUMINIUM-TIMBER STRUCTURE FOR INTERNAL MEZANINE
ALUMINIUM PLANE STRUCTURES
Rolling mill roof
(Krenzlingen, CH)
ALUMINIUM PLANE STRUCTURES

Hangar
(Hatfield, England)
ALUMINIUM PLANE STRUCTURES

Sporthall
(Gand, Belgium)
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ALUMINIUM PLANE STRUCTURES

Warehouse
(Antwerp, Belgium)
ALUMINIUM PLANE STRUCTURES

Melsbroek airport
(Brussels, Belgium)
Roof of the tribune of the football stadium in Guayaquil (Equador)
ALUMINIUM PLANE STRUCTURES

Lecheria la Gran Via in Sincelejo City (Colombia)
ALUMINIUM PLANE STRUCTURES

Swimming-pool roof in Bogotà (Colombia)
ALUMINIUM PLANE STRUCTURES

Urban Recreation Center “Compensar” (CUR) in Bogotá (Colombia)
ALUMINIUM PLANE STRUCTURES

Universidad del Norte in Barranquilla (Colombia)
ALUMINIUM PLANE STRUCTURES

Aluminium Center in Utrecht (Holland)

“The Aluminium Forest”: 368 tubolar columns
ALUMINIUM PLANE STRUCTURES

Aluminium Center
in Utrecht (Holland)

Micha de Haas
ALUMINIUM RETICULAR SPACE STRUCTURES
Erection phases of the Interamerican Exhibition Center of San Paulo (Brazil, 1969)

- Number of nodes: 13,724
- Number of bolts: 550,000
- Number of bars: 56,820 (total length: 300 km)

- Weight: 16 kg/m²
- Covered area: 67,600 m²
- Erection time: 27 hours
- Mesh size: 60x60
THE INTERAMERICAN EXHIBITION CENTRE (SAN PAOLO, BRASIL)
THE INTERAMERICAN EXHIBITION CENTRE OF SAN PAOLO (BRASIL)
THE INTERAMERICAN EXHIBITION CENTRE OF SAN PAOLO (BRASIL)
The International Congress center of Rio de Janeiro (Brazil)
Industrial buildings (Brazil)

ALUMINIUM RETICULAR SPACE STRUCTURES
Library “Luis Angelo Arango”

Bogotà (Colombia)

ALUMINIUM RETICULAR SPACE STRUCTURES
ALUMINIUM RETICULAR SPACE STRUCTURES

Mall in Bogotà (Colombia)
Hatogrande Country Club
Bogotà (Colombia)
Traffic Office
in Zapaquirà
(Colombia)
Swimming pool in Zerrezuela (Colombia)

ALUMINIUM RETICULAR SPACE STRUCTURES
Colegio Agustiniano in Bogotà (Colombia)
Centro Comercial “Salitre Plaza” in Bogotà

ALUMINIUM RETICULAR SPACE STRUCTURES
ALUMINIUM RETICULAR SPACE STRUCTURES

Empresas Publicas de Medellin
ALUMINIUM RETICULAR SPACE STRUCTURES

Building in Cali (Colombia)
THE PALASPORT OF QUITO (EQUADOR)
The Memorial Pyramid in La Baie (Quebec, Canada)

ALUMINIUM RETICULAR SPACE STRUCTURES
THE MEMORIAL OF LA BAY (QUEBEC)
Shanghai Pudong Natatorium

A 42,000 sq. ft. double layer grid vault roof

APPLICATIONS IN CHINA

Shanghai Opera House

Shanghai Opera House

APPLICATIONS IN CHINA
RECENT APPLICATIONS IN U.K.
ALUMINIUM RETICULAR SPACE STRUCTURES IN ITALY
The structure of the Congress Center of Alghero
A proposal for the roof of the Olimpic Stadium in Rome (1990)
FULL SCALE TEST
THE GEO-SYSTEM (ITALY)
“MERCATI TRAIANEI” MUSEUM (ROME)
“MERCATI TRAIANEI” MUSEUM (ROME)

Before restoration

After restoration
“MERCATI TRAIANEI” MUSEUM (ROME)

Plane reticular space structure
Reticular cylindrical vaults
“MERCATI TRAIANEI” MUSEUM (ROME)

Reticular geodetic dome
“MERCATI TRAIAINEI” MUSEUM (ROME)

Reticular geodetic dome
“MERCATI TRAIAINEI” MUSEUM (ROME)
ALUMINIUM DOMES
ALUMINIUM DOMES

Dome of Discovery built in London for the Festival of Britain (1951)

Three-directional reticulated arches

Diameter 110 m

Weight 24 kg/m²
ALUMINIUM DOMES

The Palasport of Paris (1959)

Diameter 61 m
ALUMINIUM DOMES

The geodetic dome of Guayaquil (Equador)
ALUMINIUM DOMES

Scientific Station at the South Pole
ALUMINIUM DOMES

The Conservatex system (USA):

erection phases
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ALUMINIUM DOMES

The Conservatex system (USA): applications

Industrial plants
ALUMINIUM DOMES

Epcot Center (Florida)

The TEM-COR system (USA)
ALUMINIUM DOMES

Bell County Arena (Temple, Texas)

The TEM-COR system (USA)
ALUMINIUM DOMES

Baylor University Ferrell Events Center (Waco, Texas)

The TEM-COR system (USA)
ALUMINIUM DOMES

University of Connecticut

The TEM-COR system (USA)
Spruce Goose Dome: erection phases

The “Spruce Goose” was the world’s largest clear-span aluminium dome 415 feet in diameter (Long Beach, California)
The “Spruce Goose Dome” (Long Beach, California)
ALUMINIUM GEODETIC DOMES FOR POWER PLANTS
ALUMINIUM GEODETIC DOMES FOR COAL STORAGE
The “TEM-COR” dome in Taiwan
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The “Geometrica” dome in Taiwan
The collapse of the “Geometrica” dome in Taiwan
ALUMINIUM GEODETiC DOMEs FOR COAL STORAGE

ENEL – CIVITAVECCHIA, ITALY (2007)
ALUMINIUM SPECIAL STRUCTURES

Motorway signs
Electrical towers
Lighting towers
Antenna towers
Hydraulic struct.
Off-shore struct.
Helydecks
ALUMINIUM SPECIAL STRUCTURES

Motorway sign supports
ALUMINIUM SPECIAL STRUCTURES

Electrical transmission towers and typical extruded cross-sections
Lighting towers
ALUMINIUM SPECIAL STRUCTURES

Aluminium towers in Naples (Italy)
100 years aluminium price

THE TOWER FOR
PARABOLIC ANTENNAS
OF THE ELECTRICAL
DEPARTMENT IN NAPLES
The Enel Tower: fabrication phases
The Enel Tower:
fabrication phases
The Enel Tower: erection phases
ENEL aluminium tower in Naples: erection phases
The Enel Tower: details
THE TOWERS OF TECCHIO’s SQUARE IN NAPLES
The “Information” Tower (Naples)
ALUMINIUM HYDRAULIC STRUCTURES

Reservoir: erection phases

Pipeline
ALUMINIUM HYDRAULIC STRUCTURES
ALUMINIUM HYDRAULIC STRUCTURES

Sewage plant (Po Sangone, Turin)
ALUMINIUM OFF-SHORE STRUCTURES

bridges

Helideck
ALUMINIUM OFF-SHORE STRUCTURES

Multistory housing: phases of fabrication
Helidecks
Helidecks
Arvida bridge in Quebec (Canada, 1950 – L = 150 m)
Motorway bridge (France)
Motorway bridge (The Netherlands)
Motorway bridges

Composite aluminium – concrete bridges: sections, test and theory
Moving Bridge at the Aberdeen Harbour
Bascule bridge (1967):
the first road bridge in aluminium
with 4m wide and 8.1 m span

Hand-pushed bridge

Moving bridges over the Göta channel (Sweden)
Continuous bridge with swing span
Moving foot bridges

Moving foot bridge in Oldersum (Germany)
Foot bridges

Foot bridge in Hem-Lenglet (France)
Foot bridges

Amsterdam (NL)

Villepinte (F)
The Gold Creek Footbridge - Valdez, Alaska (USA)
Foot bridge in Jonquière (Quebec, Canada)
Foot bridges

A cable-stayed foot bridge, designed for the City of Science in Naples (Italy)
A cable-stayed foot bridge, designed for the City of Science in Naples (Italy)
Military bridges

U.K. bridges
German military bridge (Dornier): erection phases
Swedish military bridge Kb 71
- Length 20 m with a theoretical span of 19 m
- Bridge depth is 0.71 m
Marina applications
Marina applications
Marina applications
Marina applications
Floating bridge with aluminium deck
Sweden (1989)
ALUMINIUM ALLOY STRUCTURES: FIELDS OF APPLICATION
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Floating road in Holland (2003)

“The new Waterway”
DECK REPARATION

Extruded decks

Paving
- 6 mm Acrydur, or
- 40 mm poured asphalt

Weight
- Aluminium deck: 50 - 70 kg/m²
- Concrete deck: 600 - 700 kg/m²
Grooves and tongues (no welds)

Span 1,0 m

Large deck profiles

Span 2,8 m
Design by testing
Old bridge cut in parts and lifted away

New bridge with aluminium deck
Deck reparation

Substitution of r.c. deck with aluminium deck
STRUCTURAL RESTORATION OF SUSPENSION BRIDGES BY MEANS OF ALUMINIUM ALLOYS
THE MONTEMERLE BRIDGE

L = 80 + 80 m

ON THE SOANE RIVER (FRANCE)
THE MONTEMERLE BRIDGE ON THE SOANE RIVER (FRANCE)
THE MONTEMERLE BRIDGE ON THE SOANE RIVER (FRANCE)
THE TREVOUX BRIDGE ON THE SAONE RIVER (FRANCE)

L = 80 + 80 m
THE TREVOUX BRIDGE ON THE SAONE RIVER (FRANCE)

L = 80 + 80 m
THE TREVOUX BRIDGE ON THE SAONE RIVER (FRANCE)
THE TREVOUX BRIDGE ON THE SAONE RIVER (FRANCE)
THE GROSLÈÈ BRIDGE ON THE RÔNE RIVER (FRANCE)

$L = 175$ m
THE GROSLÈE BRIDGE ON THE RÔNE RIVER (FRANCE)
THE GROSLÈE BRIDGE ON THE RÔNE RIVER (FRANCE)
THE GROSLÈE BRIDGE ON THE RÔNE RIVER (FRANCE)
STRUCTURAL RESTORATION OF THE “REAL FERDINANDO” BRIDGE: the first iron suspension bridge in Italy
THE “REAL FERDINANDO” BRIDGE ON THE GARIGLIANO RIVER (ITALY)

Designer: Luigi Giura

The “Maria Cristina” Bridge on the Calore river (1835)

The “Real Ferdinando “Bridge on the Garigliano river (1832)

The “Real Ferdinando” Bridge on the Garigliano river (1832)
THE “REAL FERDINANDO” BRIDGE
ON THE GARIGLIANO RIVER (ITALY)

Design data (geometry)

- $L = 85\ m$
- Distance between suspension chains $5,83\ m$
- Vertical ties every $1.37\ m$
- Two longitudinal iron beams with rectangular cross-section
- Transversal wooden beams every $1.73\ m$
- Two couples of piers made of calcar stone
- Chain anchorage at $24\ m$ from piers and $6\ m$ depth
- Chains made of pinned iron plated elements
THE “REAL FERDINANDO” BRIDGE
ON THE GARIGLIANO RIVER (ITALY)

Design data (loads and stresses)

- Dead load : 260 kg/mq
- Live load   : 240 kg/mq
- Maximum axial force in chains : 500 t
- Maximum stress in iron chains : 15 kg/mmq
- Strength of stone : 600 kg/cmq
Erection data (1828 – 1832)

- Work period: four years
- Iron: 70,000 kg
- Cost: 75,000 ducats
- Loading test: 2 groups of lancers
  - 16 artillery carriages
- Proof engineer: king Ferdinand II (?)
THE “REAL FERDINANDO” BRIDGE
ON THE GARIGLIANO RIVER (ITALY)

Special device for connecting the chains to the piers
THE "REAL FERDINANDO" BRIDGE ON THE GARIGLIANO RIVER (ITALY)
THE “REAL FERDINANDO” BRIDGE

1944 - 1990

The piers
THE “REAL FERDINANDO” BRIDGE

The top of the pier

The chain
THE “REAL FERDINANDO” BRIDGE

The sphinx
THE “REAL FERDINANDO” BRIDGE

The design of restoration
THE “REAL FERDINANDO” BRIDGE

Results of the numerical analysis

- The structural scheme gives a good performance under uniformly distributed vertical loads only.
- Due to the “mechanism” feature of the structural scheme, it is too flexible under non symmetrical loading conditions.
- The lack of bracing systems makes it unable to resist horizontal actions (wind, earthquake) without large deflections.
- The design live load (240 kg/mq) is too low even for pedestrian use.
THE “REAL FERDINANDO” BRIDGE

Basis criteria for the structural restoration design

- **Conservation of the original shape:**
  consolidation of piers;
  keep the same shape of chains (two groups per sides);
  keep the same spanning among the vertical ties,
  corresponding to the mash of the rails;
  keep the same structural scheme of the deck.

- **Increase the flexural stiffness both vertical and horizontal:**
  main longitudinal Vierendeel beams, whose mash corresponds to the vertical ties;
  rigid transversal beams;
  horizontal cross bracings with a mash of $5.83 \times (3 \times 1.37)$ m.

- **Use of modern technologies and materials:**
  high strength steel for cables;
  use of aluminium alloys instead of steel for deck.
THE NEW “REAL FERDINANDO” BRIDGE
The structures of the deck

THE NEW “REAL FERDINANDO” BRIDGE
THE NEW “REAL FERDINANDO” BRIDGE

Lateral supports
and horizontal bracings
1998: the first aluminium bridge in Italy

THE NEW “REAL FERDINANDO” BRIDGE
NON STRUCTURAL APPLICATIONS: FACADES AND ENVENLOPS
SELFPRIDGES MALL IN BIRMINGHAM (Jan Kaplicky):
Envelop made of 15,000 aluminium disquettes
ARCHITECTURAL COMPETITION

Sustainable Mediterranean architecture with aluminium facades
ARCHITECTURAL
COMPETITION
ARCHITECTURAL COMPETITION

The winner

The Touring Hotel (Italy)
THANK YOU VERY MUCH FOR YOUR KIND ATTENTION