Integral Design Studio
Institute of Structural Design

BA Dipl. Arch. Martin Knight FRIBA FICE Hon FIstructE
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Obligated Courses
Material - structure - form
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Big Scale - High and wide-spanning supporting structures
BA Dipl. Arch. Martin Knight FRIBA FICE Hon FIstructE

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Wolfgang Humer
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Front page: Kienlesbergbrücke, Knight Architects; illustrated by Helmut Kalcher

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Graz, Winter term 2021/22
The Institute of Structural Design was pleased to welcome back Martin Knight as the visiting professor for the winter term 2021. Under his supervision the students of the Integral Design Studio designed a highway bridge with an integrated bicycle bridge over the Mur river in the southern urban area of Graz. The task linked the necessary renewal of the already existing A2 highway bridge with a bicycle bridge, planned by the City of Graz as well as Feldkirchen bei Graz and Gössendorf, as an important infrastructure link between the west and east banks of the Mur.

A special challenge in the task posed the 110kV high-voltage power line running directly above the construction site which limited the construction height above the bridge deck to about 12 metres, with a minimum span of 75 metres over the river. The students faced this challenge with different design concepts: various types of cable-stayed bridges, beam bridges, truss bridges and arch bridges were created.

The choice of materials for the bridge construction was up to the students, however, a conscious use of resources in terms of sustainability was required. In order to be able to develop an estimation of CO₂ pollution, all students carried out a simplified LCA (Life Cycle Assessment) analysis. This shows in figures how much CO₂ the construction of the bridge is emitting during its entire lifespan - the calculations were made from the production of the raw materials (steel, concrete, etc.) to transport and construction to dismantling/dismantling and recycling or disposal.
S. 6
Jana Maria-Luise Engel

S. 12
Pablo González Negro

S. 18
Nora Hoti

S. 24
Wolfgang Humer

S. 30
Katarina Jovanovic

S. 36
Helmut Kalcher

S. 42
Celine Fabienne Kapper
Table of contents

S. 48
Sarah Korpitsch

S. 54
Victoria Mayer

S. 60
Aleksandar Miljkovic

S. 66
Philipp Misterek

S. 72
Javier Nuñez Cuevas

S. 78
Theresa Reif

S. 84
Corinna Schlömmer
The project was designed based on the four principles of bridge design, WHY, WHO, WHAT and HOW. By providing a connection between the opposite riverbanks, the bridge creates an additional, much needed crossing-point over the Mur. The cycle and pedestrian bridge have been positioned in the north, which creates on the one hand, the most direct connection between Feldkirchen and Graz and on the other hand also connects the economical hot-spots from both sides of the river. The bridge consists of three main elements, which are connected as one. Three arches are holding two decks for the highway, connected with cables while on the north side the cycle bridge is creating a large cantilever, suspended on the outer beam. By forming this protruding element, the bridge is creating a connection with the environment, the local people and economy as well, as there is a rowing club nearby and a few restaurants. Also, it creates a distance between the highway and the people passing the cycle bridge, providing an enjoyable passing as well as an invitation to linger.
Fig. 2: Isometric cross section
Fig. 5: Cross section 1

Fig. 6: Cross section 2
Fig. 7: Perspective view on the highway bridge

Fig. 8: Perspective view under the bridge

Fig. 9: Longitudinal section
The highway bridge had quite a few premises to keep in mind. These being the 2 phase construction process or avoiding the tension cables which constrained the possible height of the bridge. I added more premises such as increasing head room under the bridge (on the water but also on the surface) to make crossing the bridge inviting instead of limiting. For this reason one of the aims of the design was to make the deck slimmer so I went with a suspension bridge. The height limitation due to the power lines made me step back from a traditional cable-stayed bridge and bet for an extradosed bridge scheme.

On the other hand pedestrian and cyclists experience was one of our priorities. The public space generated on both ends aims to have a low impact on the existing natural and green atmosphere. The low gradient of the slopes (2%) and the south orientation for the pedestrian pathway aim to produce an enjoyable and comfortable livability for users.

There are 3 hexagonal girders inspired by the one that can be found on Santiago Calatrava’s Puente del Alamillo, which was my case of study in the beginning of the semester. The box girders consist of metal plates and T steel profiles, also they have inner stiffeners so its not exactly hollow. The cyclist’s perspective shows the difference in height and the cozy space generated. Then there is a view from the water where we can see how it adapts to the tension cables. The driver’s perspective shows the bridge as a recognisable element in the highway that connects Graz and Wien.
Fig. 11: Isometric cross section

Fig. 12: Site plan
Fig. 13: South elevation

Fig. 14: Floor plan
Fig. 15: Cross section 1

Fig. 16: Cross section 2
Fig. 17: Construction details

Fig. 18: Perspective view on the pedestrian bridge
Fig. 19: Perspective view

Nora Hoti
Fig. 20: Isometric cross section

Fig. 21: Site plan
Fig. 22: North elevation

Fig. 23: Floor plan
Fig. 24: Cross section 1

Fig. 25: Cross section 2
Fig. 26: Perspective aerial view

Fig. 27: Perspective view on the highway bridge

Fig. 28: Perspective aerial view
The bridge is generally divided in three categories. First was people and nature. How can I improve the area for residents, cyclists and pedestrians. Second, the bridge should fit into the area, have an elegant design and represent Styria and Graz. And third: an effective construction that is oriented towards the forces and does not waste unnecessary material in order to also keep the ecological footprint as low as possible.

To improve the area for people, the basic idea was to open up the area under the bridge for pedestrians and cyclists and make it much more inviting, as well as to integrate the cycle path into the existing network as much as possible because the cyclists and pedestrians can perceive the bridge best.

That’s why I moved the foundations of the bridge 20 metres from the bank of the Mur to allow cyclists and pedestrians to see the space behind, so that the bridge doesn’t look like a border but invites them to cross it. It also gives plants and animals a chance to cross the highway and resulting in a healthier forest.

The soil that is exposed for this purpose can be used directly for the loop of the bicycle ramp. Because we are already further away from the city here and should be used more as a recreational area, the cycle path will be integrated into nature and the Auwiesen will be enhanced as a result.
The design of the bridge is based on the idea of reflecting the hilly landscape of Styria and is also intended to become a landmark of the city of Graz, as the bridge is located exactly on the border to the city of Graz. The bridge can also be seen from the air and should also have a lasting impression on motorists. Thus, every motorist knows where he is when he crosses the bridge and can thus establish a relationship to the city.

This is how the wave shape came about, which is additionally braced with transverse ribs that also have a wave shape to enhance the visual effect. The wave form is not symmetrical to make the bridge look different from every angle. The shape was also chosen so as not to interfere with the power line. At the same time, the supporting structure is also a noise barrier around the neighbouring residents.

The colour concept is intended to reflect the view into the distance, which is why the front girders are darker than the rear ones and for drivers the ribs in the rear-view mirror are painted in red. The shape is adapted to the moment curve, which was optimised in the RFEM.

![Isometric cross section](image-url)
Fig. 31: South elevation

Fig. 32: Floor plan
Dam target Waterlevel = +330.80

Wall +331.10

Wsp.HQ1000 +331.52

Wsp.HQ100 +330.63

Mean groundwater level +327.50

Riverbed +326.02

Steel covered with Rost protection

Handrail in Stainless steel with integrated LED lighting

1x Cast iron pipeline ca. DN500 - Waste Water

2x DN600 district heating pipes fixed with suspended frame

Steelplate 1.5 cm, Quartz sand coated

Steel Beam 63 cm

3x stainless steel pipe with telecommunication cable and power lines

1x Cast iron pipeline ca. DN150 - Water

Asphalt 12 cm

Concrete Deck 25 cm

Steel Beam 83 cm

1,5%

1,20 17,025 1,80

3,32 0,63 0,32 5,70

3,045 0,30 1,30 6,945

3,17 5

52,1

07,4

1,20 17,025 1,80

3,61 0,30 1,20

4,3% 4,3%

2,5%2,5%

2,5%2,5%

Fig. 33: Cross section 1

Fig. 34: Cross section 2
Fig. 35: Perspective aerial view

Fig. 36: Perspective view on the pedestrian bridge

Fig. 37: Exploded axonometric view
The task is to replace the bridge in the south of Graz where the highway A2 crosses the river Mur. In addition to that, we should add a pedestrian and cycling bridge and connect the two riverbanks. The surrounding of the construction site is full of nature with cycling paths along the riversides. Northeast is a housing estate and south-east a nature reserve and areas of recreation with a barbecue space. To keep in mind, the goal was to keep the traffic flowing, interfere as little as possible with the conservation area and make the environment inviting and recreational for residents and visitors. A challenge is that there is not much space for the design, both upwards and downwards, since the upper edge of the river and the high-voltage power line, crossing over the bridge, only provide a few meters of clearance. First the supports of the bridge were set further back, and the two independent highway bridges were pulled apart to create more space and lightness for the people passing underneath. This results in a span of 95m and width of 40m for the highway bridge. The structure is a concrete truss, where you can read the force transfer from the progressively steeper triangles towards the support. The triangles are rounded due to the material use and closed with translucent plexiglass to help with the sound reduction.
The walls at the beginning and ending of the Bridge should symbolize the entry and exit of Graz and represent a welcome and goodbye hug, also a big factor was it helping with the sound reduction. The entire “truss wall” is three-dimensional, which creates different shadow patterns on the construction. The Plexiglass panels are illuminated at night and due to their translucency the shadow play is repeated. The position of the pedestrian and cycling bridge is chosen so that the two already existing highest points of the riverbanks are connected (about 40 & 60m distance to highway bridge). This enables enough space for the construction and water sports enthusiasts passing underneath. The distance to the superstructure also allows a visual relationship and the chance for visitors to view the highway bridge. The construction is a box girder that is delivered in 3 parts to the construction site (span: 2x 29m, 1x 30m). The bridge has a gradient of 4%, has its high point in the middle and is held by two additional supports in the water. It is a light construction and therefore stands as a contrast to the more massive highway bridge. There is the opportunity to view each bridge from different perspectives, which should create a space in nature that one wants to walk through and investigate.
Fig. 40: South elevation

Fig. 41: Floor plan highway bridge
The pedestrian & bycicle bridge is pre fabricated in three separate steel box griders (S355) with the spans of 29,02; 30,02 and 29,02 meters. They rest on the two piers in the river and the riverbanks. The connecting points are welded.

- Fig. 42: Cross section highway bridge
- Fig. 43: Cross section pedestrian bridge
- Fig. 44: Floor plan pedestrian bridge
The pedestrian & bicycle bridge is pre-fabricated in three separate steel box griders (S355) with the spans of 29,02, 30,02, and 29,02 meters. They rest on the two pillars in the river and the riverbanks. The connecting points are welded.

**Fig. 45:** Exploded axonometric view

**Fig. 46:** Perspective view on the pedestrian bridge
Taking inspiration from the hilly landscape around the city of Graz the design of the highway bridge evolved its wavelike form, however its form is also optimized in terms of the diagram of moments.

The highway bridge is constructed as a ladder beam with 3 steel box girders as continuous main beams and their cross beams, all of which are supported by steel columns placed near the river Mur. As the middle beam is carrying the most load, it has a supporting truss system.

For the pedestrian bridge I was thinking a lot about how the users feel when using it, so I was asking myself „Does it need to be solely functional? Or can a bridge actually be fun in some kind as well?“ So I developed this thought further and wanted to create some kind of fun experience while crossing the bridge.

By opening up the space underneath the bridge and placing the main abutments farther away from the Mur - I was able to create a space underneath the bridge that is not as dark and uninviting as it is now but rather have a welcoming and useful place here. I was thinking of a bike pump track on one side to further expand this recreation area which is nearby.
The ramp has such a slight gradient you might forget that it actually still is a ramp - because too high slopes might prevent people from using it. The ramp or the path is slithering through the local recreation area so that users can not only enjoy the view on the bridge but rather have some kind of positive experience for the whole bridge.

The pedestrian bridge is constructed as a hybrid of a conventional and a self-anchored suspension bridge. It spans 3 steel wire cables in the middle which connect with the underlying steel box girder and are redirected over this fan-shaped pylon which is acting as a saddle. In the middle of the bridge the steel wire cable is completely gone as the box girder underneath is taking the forces as a tension member and therefore this huge area in the middle of the bridge is created where you can move freely. To avoid torsion forces it is also connected through box girders to the main bridge.

It is slender and elegant, and the relationship between the highway and pedestrian bridge is harmonious and attractive. They suit each other, not just in the wave form but in the contrast of solid steel (compression) for the highway bridge and the transparent (tension) of the footbridge while interacting with the hills in the background and blending into the landscape.
Fig. 55: Perspective view from the recreational area

Fig. 56: Perspective view on the pedestrian bridge

Fig. 57: Perspective aerial view
Celine Fabienne Kapper

Creating an outstanding landmark that meets the needs of all users and fits into the surroundings. Connecting them not only east to west but also north to south, leaving more space underneath the bridge as well as bringing more light to the underpass for a more pleasant space to enjoy the nature around it.

The hierarchy of the pylons creating an exciting shape of the bridge and giving it a rather unique look. Two higher pylons on each side symbolizing the entrance and exit of the borderline to Graz. The shape is also given by the environment around it. To avoid the contact between the high voltage cables, smaller pylons are located near to them.

A recognizable structure seen within miles away (eg. airplane) as well as up close (eg. car, bike, pedestrian) which also works as a meeting point, a destination and a memorable place to drive over, under and through.

A longlasting and durable structure with a low ecological impact. Using steel as the superior material produced by a local company.
Fig. 59: Isometric cross section
Fig. 60: Longitudinal section

Fig. 61: Floor plan
Fig. 62: Cross section 1

Fig. 63: Cross section 2
Fig. 64: Perspective view on the highway bridge

Fig. 65: Perspective view under the bridge

Fig. 66: Perspective view on the pedestrian bridge
As the title says, one bridge becomes two. At first glance, they are two completely different bridges, but if you look more closely, you can see the same shape in each bridge, only mirrored.

Both bridges connect the east and west banks of the Mur. Nevertheless, both bridges have different functions, to carry loads and means of transport. The constructions of the bridges try to reflect this. The highway bridge is very massive with the 8 concrete girders. Strong enough to withstand the daily rush hour traffic. The foot and cycle bridge shows the opposite with the light construction. It is only supported by two solid wood A-beams.

The new design of the bridges is intended to bring new life to the connection between east & west, and of course also between south & north, and to enhance the landscape around the Auwiesen.
Fig. 68: Cross section pedestrian bridge

Fig. 69: Perspective view
Fig. 70: South elevation pedestrian bridge

Fig. 71: Floor plan highway bridge
Fig. 72: Cross section 1

Fig. 73: Cross section 2
Fig. 74: Perspective view under the bridge

Fig. 75: Perspective view

Fig. 76: Perspective view
The bridge will be extended by 20 meters on each side. Thus the original 85 meters will become 125. 3 spans will be created. The newly created space under the bridge will serve to enlarge the bicycle and pedestrian paths, as well as a recreation room and exhibition space.

By opening the two lanes in the middle, light gets under the bridge. For both pedestrians and cyclists, as well as rounders, the area under the bridge becomes more attractive. This makes the space under the bridge a place where people like to spend time.

The existing network of cycle paths is used, built up and extended. Thus new connections are created. The two banks of the Mur are connected by the pedestrian and bicycle bridge. In addition, the new bridge makes it possible to link various areas with each other. Murau-en, industrial company areas and residential areas in the east are connected with nature, settlement areas and the airport in the west.

To keep the structure under the bridge as thin as possible, the supporting structure is above the roadway. The structure itself principally consists of three different truss girders. The black lines show the optimal force curves of a framework. The gray hatches show the construction of my bridge. The middle girder consists of steel boxes that interlock with each other.
Fig. 78: Isometric cross section

Fig. 79: Exploded axonometric diagram

Fig. 80: Some early concept sketches
Fig. 81: South elevation

Fig. 82: Floor plan
**Fig. 85:** Perspective view on the highway bridge

**Fig. 86:** Perspective view under the bridge
Aleksandar Miljkovic

In the south of Graz, in a recently redesigned recreational area, this highway bridge connects the two banks of the Mur in Graz. The current situation is that it is a noisy and uninviting place without the possibility for cyclists and pedestrians to cross the river. The aim is to allow traffic to continue to flow efficiently from A to B, to offer residents a more quiet place and to increase the quality of stay at the recreational area.

The abutments were moved outwards to create more openness, the spans were reduced in parallel to apply a slimmer construction to achieve more headroom under the bridge and lift up the path to be higher than the water level. A curved barrier-free bicycle and pedestrian bridge uses the highway bridge as a constructive aid and the columns are moved to the river bank.

The construction is a steel-concrete hybrid structure. The choice of this construction method allows efficient formwork of the monolithic concrete elements on land, which transfer the forces and loads of the steel trusses and at the same time serve as a counterweight for the cantilevered bicycle bridge. After the construction of the concrete part, the trusses are placed on the concrete land bridge.

To avoid the noise, the truss openings are closed with transparent glass with the possibility to insert in the southside a photovoltaic system instead of glass. In the middle of the bridge is a curved spatial steel truss, covered in the same color as the concrete part with translucent glass and is only visible after sunset when the light is activated from the inside of the spatial truss. Due to the inclination and curvature of the truss, the noise from the inside of the highway is reflected upwards.
Fig. 88: Isometric cross section

Fig. 89: Site plan
Fig. 90: South elevation

Fig. 91: Floor plan
Fig. 92: Cross section 1

Fig. 93: Cross section 2
Fig. 94: Perspective view on the highway bridge

Fig. 95: Perspective view on the pedestrian bridge

Fig. 96: Perspective view under the bridge
Philipp Misterek

My design principles:
Creating a recognizable landmark that interacts with the place and reinforces its status as the southern entrance of Graz.
Translating the northern topography of Graz into a functional structure.
Creating a transition between the recreational areas (west) and the suburb (east).
High construction above the deck to significantly increase the head space below while not interfering with the existing high voltage line above.
Creating interesting lines of views along the pedestrian / bicycle path axes.

Highway bridge:
Cable-stayed, fully elevated steel ladder beam construction supporting the slim concrete deck.
Pylon form design as a reaction to the static forces.
Illuminated bridge underside.

Foot-/bicycle bridge:
Continuous hollow steel beam which separates itself for the wider part of the ramp. Supported by as few supports as possible.
Slim concrete deck with oak wood planks and glass railing.
Fig. 98: Isometric cross section
Fig. 101: Axonometric site diagram

Fig. 102: Cross section 1
**Fig. 103:** Cross section 2

**Fig. 104:** Perspective view under the bridge

**Fig. 105:** Perspective view on the highway bridge
Javier Nuñez Cuevas

The project’s aim is to connect the two riverbanks of the Mur for both pedestrians, cyclists and drivers, and in that process, create a space that improves the site and the experience of the users. The main purpose is to create a bridge that belongs to the site, a bridge that enters the landscape, enriches the area and creates a one of a kind experience in its crossing. To build an icon. The bridge is located in the south edge of the city of Graz. This will lead us to think that in the future, with the developing of the city, it could become an important area of the future bigger city. Because of that, the design is not only for now, but also for the future. Right now, we could separate 4 areas, 2 on each riverbank. The residential area is in the northeast, green recreational area is in the southeast, and then on the other side, we have a forest in the northwest, then the nature continues to the southwest.

The design wants to connect the nature of the two riverbanks with a path that develops through an apparently aleatory column grid below the highway. This grid is disposed in a way that the columns alter the less the course of the river, so in that direction the impact will be minimum. When it comes to the direction that the people crossing the bridge will see, it will look like an aleatory forest of columns, even though it is not. The project has two very different parts, the highway bridge, and the pedestrians and cyclists path. In this sense, the design embraces the contrast and separates these two areas due to the difference in enjoyment time between them. The experience of a driver will be approximately 7 seconds, and the experience of a walker or a cyclists will take as long a he wishes. Thus, two streams of movement are created at different heights, and two very different experiences for each user.
Fig. 107: Isometric cross section 1

Fig. 108: Isometric cross section 2
Fig. 109: South elevation

Fig. 110: Floor plan
Fig. 111: Cross section 1

Fig. 112: Cross section 2
Fig. 113: Perspective view from the recreational area

Fig. 114: Exploded axonometric view
Fig. 115: Perspective view

Fig. 116: Some early concept sketches
Theresa Reif

Fig. 117: Detail 1

Fig. 118: Detail 2
Fig. 119: South elevation

Fig. 120: Floor plan
Fig. 121: Cross section 1

Fig. 122: Longitudinal section 1
Fig. 123: Perspective view on the highway bridge

Fig. 124: Perspective view on the pedestrian bridge
In my bridge design, one of the first points I wanted to accomplish was to open up the space underneath the bridge. Therefore, I decided to build a truss bridge, so that the main construction is above the street. To block the sound of the traffic, I decided to close the holes of the truss with a noise-canceling wall. I thought this was really important, especially because of the pedestrian and cycling bridge that is directly connected to the main bridge. Also, to make it more attractive to pass though under the bridge I decided to have inclined foundations, so the pathway underneath gets wider.

Furthermore, to be able to go up to the bridge faster there are additional stairs, so you don’t have to walk up on the ramp.

The truss is made from corten steel to have minimal amount of maintenance, and to have a really memorable point on the highway to and from Graz. The project consists of three parallel trusses. Both the upper belt and the lower belt have a slight lycurved shape. Towards the outside, the cross-section of the upper and lower belt becomes gradually smaller. The struts in between also have different cross-sections tailored to the respective load.

The noise-canceling wall in the holes of the truss is made from translucent noise-canceling plastic panels, so when you pass over the bridge with the car you can still notice the nature and river you are passing by.
Fig. 126: Isometric cross section

Fig. 127: Section detail 1 of abutment

Fig. 128: Section detail 2 of abutment

Fig. 129: Section detail 3 of abutment
Fig. 130: South elevation

Fig. 131: Floor plan
Fig. 132: Cross section 1

Fig. 133: Cross section 2
Fig. 134: Perspective view under the bridge

Fig. 135: Perspective view on the highway bridge

Fig. 136: Perspective view on the pedestrian bridge
Table of figures

Fig. 1: Perspective view on the pedestrian bridge, Jana Maria-Luise Engel
Fig. 2: Isometric cross section, Jana Maria-Luise Engel
Fig. 3: North elevation, Jana Maria-Luise Engel
Fig. 4: Floor plan, Jana Maria-Luise Engel
Fig. 5: Cross section 1, Jana Maria-Luise Engel
Fig. 6: Cross section 2, Jana Maria-Luise Engel
Fig. 7: Perspective view on the highway bridge, Jana Maria-Luise Engel
Fig. 8: Perspective view under the bridge, Jana Maria-Luise Engel
Fig. 9: Longitudinal section, Jana Maria-Luise Engel
Fig. 10: Perspective view from the river Mur, Pablo González Negro
Fig. 11: Isometric cross section, Pablo González Negro
Fig. 12: Site plan, Pablo González Negro
Fig. 13: South elevation, Pablo González Negro
Fig. 14: Floor plan, Pablo González Negro
Fig. 15: Cross section 1, Pablo González Negro
Fig. 16: Cross section 2, Pablo González Negro
Fig. 17: Construction details, Pablo González Negro
Fig. 18: Perspective view on the pedestrian bridge, Pablo González Negro
Fig. 19: Perspective view, Nora Hoti
Fig. 20: Isometric cross section, Nora Hoti
Fig. 21: Site plan, Nora Hoti
Fig. 22: North elevation, Nora Hoti
Fig. 23: Floor plan, Nora Hoti
Fig. 24: Cross section 1, Nora Hoti
Fig. 25: Cross section 2, Nora Hoti
Fig. 26: Perspective aerial view, Nora Hoti
Fig. 27: Perspective view on the highway bridge, Nora Hoti
Fig. 28: Perspective aerial view, Nora Hoti
Fig. 29: Perspective view from the recreational area, Wolfgang Humer
Fig. 30: Isometric cross section, Wolfgang Humer
Fig. 31: South elevation, Wolfgang Humer
Fig. 32: Floor plan, Wolfgang Humer
Fig. 33: Cross section 1, Wolfgang Humer
Fig. 34: Cross section 2, Wolfgang Humer
Fig. 35: Perspective aerial view, Wolfgang Humer
Fig. 36: Perspective view on the pedestrian bridge, Wolfgang Humer
Fig. 37: Exploded axonometric view, Wolfgang Humer
Fig. 38: Perspective view on the highway bridge, Katarina Jovanovic
Fig. 39: Isometric cross section, Katarina Jovanovic
Fig. 40: South elevation, Katarina Jovanovic
Fig. 41: Floor plan highway bridge, Katarina Jovanovic
Fig. 42: Cross section highway bridge, Katarina Jovanovic
Fig. 43: Cross section pedestrian bridge, Katarina Jovanovic
Fig. 44: Floor plan pedestrian bridge, Katarina Jovanovic
Fig. 45: Exploded axonometric view, Katarina Jovanovic
Table of figures

Fig. 46: Perspective view on the pedestrian bridge, Katarina Jovanovic
Fig. 47: Perspective view on the pedestrian bridge, Helmut Kalcher
Fig. 48: Isometric cross section, Helmut Kalcher
Fig. 49: Exploded axonometric view and potential construction procedure, Helmut Kalcher
Fig. 50: South elevation, Helmut Kalcher
Fig. 51: Floor plan, Helmut Kalcher
Fig. 52: Cross section 1, Helmut Kalcher
Fig. 53: Cross section 2, Helmut Kalcher
Fig. 54: Cross section 3, Helmut Kalcher
Fig. 55: Perspective view from the recreational area, Helmut Kalcher
Fig. 56: Perspective view on the pedestrian bridge, Helmut Kalcher
Fig. 57: Perspective aerial view, Helmut Kalcher
Fig. 58: Perspective view, Celine Fabienne Kapper
Fig. 59: Isometric cross section, Celine Fabienne Kapper
Fig. 60: Longitudinal section, Celine Fabienne Kapper
Fig. 61: Floor plan, Celine Fabienne Kapper
Fig. 62: Cross section 1, Celine Fabienne Kapper
Fig. 63: Cross section 2, Celine Fabienne Kapper
Fig. 64: Perspective view on the highway bridge, Celine Fabienne Kapper
Fig. 65: Perspective view under the bridge, Celine Fabienne Kapper
Fig. 66: Perspective view on the pedestrian bridge, Celine Fabienne Kapper
Fig. 67: Perspective view, Sarah Korpitsch
Fig. 68: Cross section pedestrian bridge, Sarah Korpitsch
Fig. 69: Perspective view, Sarah Korpitsch
Fig. 70: South elevation pedestrian bridge, Sarah Korpitsch
Fig. 71: Floor plan highway bridge, Sarah Korpitsch
Fig. 72: Cross section 1, Sarah Korpitsch
Fig. 73: Cross section 2, Sarah Korpitsch
Fig. 74: Perspective view under the bridge, Sarah Korpitsch
Fig. 75: Perspective view, Sarah Korpitsch
Fig. 76: Perspective view, Sarah Korpitsch
Fig. 77: Perspective view on the pedestrian bridge, Victoria Mayer
Fig. 78: Isometric cross section, Victoria Mayer
Fig. 79: Exploded axonometric diagram, Victoria Mayer
Fig. 80: Some early concept sketches, Victoria Mayer
Fig. 81: South elevation, Victoria Mayer
Fig. 82: Floor plan, Victoria Mayer
Fig. 83: Cross section 1, Victoria Mayer
Fig. 84: Cross section 2, Victoria Mayer
Fig. 85: Perspective view on the highway bridge, Victoria Mayer
Fig. 86: Perspective view under the bridge, Victoria Mayer
Fig. 87: Perspective aerial view, Aleksandar Miljkovic
Fig. 88: Isometric cross section, Aleksandar Miljkovic
Fig. 89: Site plan, Aleksandar Miljkovic
Fig. 90: South elevation, Aleksandar Miljkovic
Fig. 91: Floor plan, Aleksandar Miljkovic
Fig. 92: Cross section 1, Aleksandar Miljkovic
Fig. 93: Cross section 2, Aleksandar Miljkovic
Fig. 94: Perspective view on the highway bridge, Aleksandar Miljkovic
Fig. 95: Perspective view on the pedestrian bridge, Aleksandar Miljkovic
Fig. 96: Perspective view under the bridge, Aleksandar Miljkovic
Fig. 97: Perspective view on the pedestrian bridge, Philipp Misterek
Fig. 98: Isometric cross section, Philipp Misterek
Fig. 99: South elevation, Philipp Misterek
Fig. 100: Floor plan, Philipp Misterek
Fig. 101: Axonometric site diagram, Philipp Misterek
Fig. 102: Cross section 1, Philipp Misterek
Fig. 103: Cross section 2, Philipp Misterek
Fig. 104: Perspective view under the bridge, Philipp Misterek
Fig. 105: Perspective view on the highway bridge, Philipp Misterek
Fig. 106: Perspective view on the pedestrian bridge, Javier Nuñez Cuevas
Fig. 107: Isometric cross section 1, Javier Nuñez Cuevas
Fig. 108: Isometric cross section 2, Javier Nuñez Cuevas
Fig. 109: South elevation, Javier Nuñez Cuevas
Fig. 110: Floor plan, Javier Nuñez Cuevas
Fig. 111: Cross section 1, Javier Nuñez Cuevas
Fig. 112: Cross section 2, Javier Nuñez Cuevas
Fig. 113: Perspective view from the recreational area, Javier Nuñez Cuevas
Fig. 114: Exploded axonometric view, Javier Nuñez Cuevas
Fig. 115: Perspective view, Theresa Reif
Fig. 116: Some early concept sketches, Theresa Reif
Fig. 117: Detail 1, Theresa Reif
Fig. 118: Detail 2, Theresa Reif
Fig. 119: South elevation, Theresa Reif
Fig. 120: Floor plan, Theresa Reif
Fig. 121: Cross section 1, Theresa Reif
Fig. 122: Longitudinal section 1, Theresa Reif
Fig. 123: Perspective view on the highway bridge, Theresa Reif
Fig. 124: Perspective view on the pedestrian bridge, Theresa Reif
Fig. 125: Perspective view, Corinna Schlömmer
Fig. 126: Isometric cross section, Corinna Schlömmer
Fig. 127: Section detail 1 of abutment, Corinna Schlömmer
Fig. 128: Section detail 2 of abutment, Corinna Schlömmer
Fig. 129: Section detail 3 of abutment, Corinna Schlömmer
Fig. 130: South elevation, Corinna Schlömmer
Fig. 131: Floor plan, Corinna Schlömmer
Fig. 132: Cross section 1, Corinna Schlömmer
Fig. 133: Cross section 2, Corinna Schlömmer
Fig. 134: Perspective view under the bridge, Corinna Schlömmer
Fig. 135: Perspective view on the highway bridge, Corinna Schlömmer
Fig. 136: Perspective view on the pedestrian bridge, Corinna Schlömmer