Composite bridges in Austria

Autor(en): **Hufnagel, Walter / Biberschick, Peter / Wenzel, Helmut**

Objekttyp: **Article**

Zeitschrift: **IABSE reports = Rapports AIPC = IVBH Berichte**

Band (Jahr): **999 (1997)**

PDF erstellt am: **24.05.2024**

Persistenter Link: https://doi.org/10.5169/seals-952

Composite Bridges in Austria

Walter HUFNAGEL
Dipl.-Ing.
MA 29
Vienna, Austria

Walter Hufnagel is Chief of the Bridge Department MA 29 in Vienna managing a big number of major bridges.

Peter BIBERSCHICK
Dipl.-Ing.
A. Pauser & Partner
Vienna, Austria

Peter Biberschick is partner and managing director of the highly reputed consulting office founded by Prof. Pauser.

Helmut WENZEL
Dr.-Ing.
VCE
Vienna, Austria

Helmut Wenzel is the Managing Director of VCE, Fritsch-Chiari Vienna Consulting Engineers.

Summary

This paper describes the situation of composite bridge construction in Austria illustrated by some representative examples. The replacement of existing structures by composite bridges predominates over newly constructed bridges. In Vienna, Nordbrücke, one of the most frequented bridges of Austria, was successfully upgraded. The work performed is described. On the basis of the dynamic characteristics of the structures, innovative methods of inspection and assessment are applied in Austria, which are also presented.

1. Introduction

Due to its topography, Austria traditionally is a country of bridge builders. The motorway network in the Alps, including the three north-south crossings of Brenner Motorway, Tauern Motorway and Pyhrn Motorway, results in a high percentage of bridges in the overall road network. Since the beginnings of reinforced-concrete bridge construction, it was tried to combine steel and concrete in a way to ensure that both materials fulfil the functions best suited to their properties in a bridge structure. This means that the compressive strength of concrete as well as the tensile strength and compressive strength of steel are used specifically, while their interaction is safeguarded by efficient and permanent doweling. In spite of the clear technical advantages of composite steel bridges, this construction method was seldom applied in Austria, as heavy competition – similar to the conditions in our neighbouring countries – made co-operation between steel and concrete construction companies difficult.

The time has not yet come when composite bridges offer advantages in economic terms. However, they meet today's higher quality standards in modern bridge construction and succeed over other construction methods, in particular, in case of difficult basic conditions. Composite construction frequently offers absolutely new design options, such as lower construction depths or low dead weights for medium-span bridges, and often allows for good solutions under difficult external conditions. In this field, composite construction can absolutely compete with prestressed concrete construction, while all-steel construction is only advantageous under extreme basic conditions in Austria. Based on the development on the European market which shows a strong increase in steel bridges, the construction of composite bridges is expected to experience a revival in Austria, too. In our view, the direct benefits of this method are as follows:

- Composite construction is a simple bridge construction method which does not require heavy temporary scaffolding during building so that the terrain below the bridge need not be used.
- Another advantage of mounting is that it takes very little time and, thus, projects can be completed earlier.
- Composite structures can be modified easily which has frequently resulted in substantial advantages when bridges had to be reinforced or widened.
- Concrete decks damaged in most cases due to the action of de-icing salt can be easily repaired, removed or replaced. Likewise, advantages are found when analysing the costs of composite bridges throughout their life. In particular, steel recycling will contribute to covering demolition costs.
- Demolition work is less difficult than in case of prestressed concrete structures.

Due to intensified competition resulting from the economic situation in Europe, steel construction has to attempt to maintain its competitiveness by cutting costs. In this context, potentials are opened up by the following:

- The advantages of composite girders, mainly as regards shear strength, have to be fully utilised. Attention, however, has to be paid to carefully detailing the connections in order to prevent damage which already occurred in the past.
- A more economical design of the reinforced web of main girders seems to be possible. By slightly raising the amount of material used, it is possible to reduce high labour costs.
- An absolutely essential advantage results from the application of concrete decks in wide-span composite girder bridges. The simple principle of using the best suited material at the right place can still be refined, as is shown by some examples.
- The utilisation of even more far-reaching innovations, such as detachable bonds, timed shifting in mounting and the use of prestressed concrete components, let us expect numerous innovative solutions for composite bridges.

2. Composite Bridges in Austria

The great majority of our composite bridges were built during the extension of the high-ranking road network in the 1960's and 1970's. This development started here, near Innsbruck, when the Inntal and Brenner Motorway was extended, and finally spread to the east in the course of the construction of other Alpine crossings and of bridges across the River Danube. Thus, we will start our presentation of examples in the west, near Innsbruck, moving east towards Vienna. Along the Brenner Motorway, there are numerous examples for the successful application of composite bridges. In the course of rehabilitation works carried out after thirty years of extreme utilisation, composite structures are executed again and again. For example, Steinbruch Bridge, a prestressed concrete bridge with a clear span of 5 x 20 m located at a hillside slope involving the risk of slides, was replaced by a composite bridge with a clear span of 100 m.

Miezener Bridge was widened without the main girders having to be reinforced. Just the wind bracings and one bridge bearing had to be reinforced. The lanes of Gschnitztal Bridge were widened in the years from 1986 to 1988 since operation demanded an additional lay-by for safety reasons. As a result, the old reinforced-concrete deck was removed and replaced by a new, thinner deck with limited transverse prestressing.

In the first place, the higher traffic load which results from the widening of the bridge lane would normally lead to an overload for the steel load-bearing system. Given the simplified calculation methods applied at that time, which were on the safe side without exception, and given the higher traffic loads in relation to the bridge width, which were stipulated at that time, it was possible to prove with today's sophisticated calculation methods that the bearing capacity is safe for the reduced traffic load permitted in relation to the increased bridge width without having to reinforce the steel load-bearing system. As these high valley bridges did not have any inspection wagons, such wagons were installed in the two superstructures before widening was started. They were screwed to each of the outer main girders by means of one vertical rail and two horizontal rails using brackets. The vehicles were designed in such a way that it was possible to use them also as mounting aids. The removal and the replacement of the deck was performed from this mounting wagon with the aid of a temporarily mounted rail.

The entire deck was removed and finally produced new section by section. From the block dowels, the loops were removed and replaced by headed shear connectors. The new reinforced-concrete deck was fully doweled also in the support zones. At the steel superstructure, only the lower wind bracings had to be reinforced by welding on cantilever segments. In order to improve fatigue strength, reinforcing butt straps were installed. Transverse prestressing of the concrete slab was performed after completion of steel construction work. In parallel to widening the bridge, its bearings and expansion joints were rehabilitated. Bearings maladjusted in construction were corrected, thus resolving the problems observed in the behaviour of the supporting structure. The examples described show that the rehabilitation and adaptation of all-steel bridges is the most cost-efficient method by far. The costs of rehabilitation amounted to an average of US $ 850 per square meter.

In the second half of the 1960's, „Pilzbrücken" – slim concrete structures with joints in every span – with a total of approx. 56,000 m² were constructed in the motorway section Innsbruck – Brenner. The supporting structure of this bridge type is produced by combining span-sized, single-support structures. „Halbpilzbrücken" with a span width of 15 m were constructed for the lane facing the valley and „Vollpilzbrücken" with a span width of 30 m for the entire cross-section of the motorway. Due to leakage in the numerous system-inherent pin joints and due to the action of the de-icing salt, corrosion heavily damaged the reinforcement and the prestressing anchors which required thorough rehabilitation. Brenner Autobahn AG invited several consulting engineers to participate in a design competition which had the objective of developing suitable rehabilitation plans taking into account the constraint that traffic could be restricted to one lane per direction, but never interrupted or detoured and that 2 x 2 lanes had to be available during the summer holidays.

The plan for the rehabilitation of Reichenbichl Bridge specified the complete renewal of the supporting structure since this seemed to be the only possibility for eliminating all the defects completely and permanently. This rehabilitation plan is based on two innovative ideas:

- Without affecting traffic, a prestressed crosshead is joined to the existing hollow stanchion of the old structure. The crosshead essentially transmits its load via friction, supported by circumferential prestressing, to the stanchion and does not need any other connecting elements.

- For the „Vollpilzbrücken", a phased removal plan was developed which was co-ordinated with the construction stages of the new composite structure. As a result, both the remaining cross-section of the old supporting structure and first parts of the new structure can take over traffic functions offering an absolutely safe bearing capacity.

This first rehabilitation project was performed on schedule from autumn 1992 to June 1995. As the implementation of the plan was successful in all respects, the client decided to have other „Pilzbrücken" rehabilitated also in accordance with this concept. At present, the design plans are implemented at Große Larchwiesen Bridge and Weber Bridge, and will also be applied to the rest of the „Pilzbrücken".

As part of the Tauern Motorway (Salzburg – Villach), Gasthofalm Bridge is located directly before the entrance to Tauern Tunnel.

Effective spans: 52.85 + 5 x 66.06 + 52.85 = 436.00 m
Bridge width: 16.25 + 13.75 = 30.00 m

The supporting structure is a composite bridge with an S-shaped layout. For each direction, a separate composite steel structure was erected. The bigger width of the lane to Salzburg results from the inclusion of a climbing lane. The two plain main girders with parallel chords per supporting structure have a construction depth of approx. 3.50 m and are continuously curved. Due to the layout of rhomb-shaped, horizontal web systems, two parallel torsion boxes are created. The composite deck made of B 400 steel has a standard thickness of 25 cm and is haunched to 40 cm at the main girders. The separate supporting structures of each direction were mounted by cantilevering in parallel and at the same time. The composite deck was erected using a formwork transport wagon with concrete being placed in a staggered way. In the support zones, concrete was placed after the span areas were finished in order to prevent tensile stress in the composite deck due to the concreting load. The total weight of the steel structure, which is mainly made up of special Alfort steel, amounts to approx. 2,000 ton, corresponding to approx. 150 kp/m².

The Altersberg hillside bridge is also located at Tauern Motorway. This bridge was designed and erected in the years 1974 to 1975. Its spans are 48 + 6 x 78 + 2 x 82 + 90 + 69 = 839 m, and its total width is 25.5 m. There is one common structure consisting of four main girders carrying a single concrete deck. The plan of the bridge shows a curvature with radii between 2,500 m and straight line. The main steel structure consists of welded plate girders (height 3,55 m) with distances of 5.5 + 7.3 + 5.5 m, partially connected with bracings and lattice cross girders. The steel qualities are St 37 T, St 44 T and ALFORT (permissible stress 288 N/mm^2). The concrete deck is of quality B 400 without prestressing. To reduce the tension stresses at hogging moments a longitudinal compression force (up to 40,000 kN) was produced by hydraulic jacks installed in gaps across the deck. To enable this the concrete plate had a slide way on the upper flange of the main girders. The erection was executed step by step from one side with a derrick crane which set in 18 m long parts of the main girder and after this was moved forward to take over the next parts. Before reaching the following pier a special pantented cantilevering „bill" was used to take over the bearing force by lifting the end of the bridge with hydraulic jacks. This action reduced the cantilever moment at the previous pier.

The Niederranna Bridge across the River Danube is located at Ebenhoch Provincial Road near Wesenufer, approximately half-way between Linz and Passau.

Effective spans: 91 + 137 + 91 = 319 m
Total width: 13.5 m

The supporting structure is a three-span composite steel bridge with continuous bond. The haunched, plain main girders have a construction depth of 3.75 m in the slab area and of 6.00 m in the support zone. The reinforced-concrete deck made of B 400 is doweled to the top chords of the main girder along the entire length of the bridge and is not prestressed in the longitudinal direction. A state-of-the-art crack-control reinforcement system prevents the formation of harmful cracks. The standard thickness of the composite deck is 25 cm which is raised to 40 cm near the main girders.

Special mention has to be made of the mounting technique. In parallel to the construction of the substructures and the piers, the prefabricated steel construction was assembled into five large elements at the right bank. These structural elements which were up to 95 m long and weighed up to 300 ton were placed by floating cranes within four days. This method did not require any mounting supports in the Danube and resulted in a substantial reduction of the construction period. In order to minimise tensile stress in the composite deck, an optimised concreting sequence was selected. The basic principle was to place the concrete in the support zones after completing the span areas. To reduce tensile stress in the composite deck even further, it was raised by approx. 1.30 m at the abutments. The total weight of the supporting steel structure is slightly below 1,000 ton, corresponding to approx. 230 kp/m².

The Steyregger Bridge across the River Danube is located at the federal road B3 and provides the area to the east of Linz with a direct connection to the industrial zone of Linz.

Effective spans: 3 x 80.6 + 161.2 + 50.6 = 453.6 m
Total width: 24.86 m

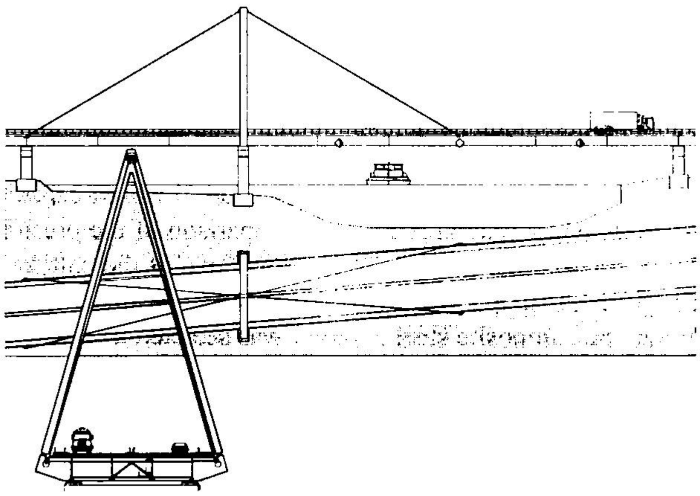

Figure 1: Steyregger Bridge across the River Danube

Since the objective was to achieve a carriageway gradient as low as possible above the clearance defined for navigation, the most economical solution was to construct a cable-stayed bridge taking into account the main navigation channel's width of 161.2 m. Comparative calculations demonstrated that composite construction was more economical than a steel deck solution. Therefore, a composite cable-stayed bridge was constructed. The bridge beam is guyed via an A-shaped pylon in the main navigation channel. The steel structure of the longitudinal girder is a continuous girder grille with four main girders and one load-distributing cross girder per span.

The reinforced-concrete deck made of B 500 is doweled to the main girder's top chords along the entire length of the bridge and pretensioned in the longitudinal direction. The deck has a thickness of 20 cm at a main girder distance of 6.4 m and is haunched to 35 cm above the main girders. The upper bracing between the inner main girders (which was placed slightly lower due to the formwork wagon) absorbs wind load before the deck hardens. In the cable installation zones, the bracing was widened to the outer main girders and allows for cable force distribution to all four main girders. The A-shaped pylon (approx. 44 m high) is based upon the cantilever arms of the pylon cross girder via pivoting point bearings. In the pylon head, the cables run across a welded saddle bearing. Each of the two cable trains is made up of 15 locked-wire strand cables, Ø 69 mm, with multi-layered round core and three Z wire bearings the outermost of which is hot-dipped galvanised. They were pre-stretched by the manufacturer.

The mounting of the bridge was started at the Steyregg end span using two temporary frames and was continued to the Linz abutment by cantilevering. In the second and third span, only the inner main girders were cantilevered to the pier from the middle of the span on while the outer ones were constructed after fixing the inner main girders. After the pylon was erected, cantilevering continued in the navigation channel. Due to the installation of the cable train, the clearance was bridged without interruption of navigation. The deck was concreted in sections with a length of approx. 40 m using a formwork wagon travelling in the top wind bracing so that tensile stress in the deck was minimised. By raising the bridge's ends, in particular the support zones 1 and 4 were relieved. Apart from longitudinal pretensioning by means of tendons (strand cable St 160/180) with a total force of 9,000 ton in the pillar zones, the deck was prestressed via the diagonal cables by raising the saddle bearing at the pylon. Due to the optimised concreting and prestressing sequence, the bonding effect was ensured along the entire bridge. The total weight of the steel construction, including the pylon, cables and installations, amounts to approx. 3,000 ton, corresponding to 260 kp/m².

Recently, composite bridges have also been used in railway construction. In the course of the expansion of the western railway line between Vienna and Salzburg, Eisenbahn-Hochleistungsstrecken AG plans to construct a by-pass near Melk in order to raise capacity while providing also a link to the existing train station of Melk. Both the high-capacity section and the by-pass cross the River Melk and a federal road. The comparison of the prestressed concrete solution and composite construction included in the specifications of the call for tenders took into account not only initial investment but also the different costs of maintenance and utilisation. Based on these conditions, the composite steel solution was selected as being more cost-efficient in the final analysis.

The two bridges have haunched plain girders. The high-capacity bridge is a four-span structure (33 m + 48 m + 33 m+ 31 m) having a total length of 146.2 m. The bridge of the by-pass follows the railway track with a radius of 700 m and is a five-span structure (53 m + 53 m + 79 m + 53 m + 36 m) having a total length of 276.2 m. The static calculations were performed according to the new Austrian standards ÖNORM B 4003 and B 4300. As there are no Austrian standards applicable to composite railway bridges, the assumptions were made in accordance with the composite road bridge standard ÖNORM B 4502. A comparative calculation according to Eurocode 1994-2 yielded good correspondence with the assumptions made. The steel grade used was S35510. Since big chords with a thickness of up to 90 mm had to be welded, thermomechanically rolled steel of the grade DIMC-355B was used for improved welding properties. For the conventionally reinforced composite deck, B 400 concrete with a thickness of 40 cm was used for the main bridge and B 500 concrete with a thickness of 50 cm for the access bridge. The steel construction was connected with the concrete deck by means of headed shear connectors. The approx. 1540 ton bridge structure was manufactured in Vienna. The individual components had a total weight of approx. 40 ton, a width of up to 5.2 m and a length of 25 m. They were delivered by special transport to the site and mounted by means of two-engine rubber-mounted cranes.

The Pöchlarn Bridge across the Danube is planned to be constructed in the course of Pöchlarn B 209 road and will link the A1 western motorway to B 3 Danube road. Two lanes and a bicycle path are to be crossed. The total width of the bridge amounts to 13.45 m. In the course of 1997, two parallel call for tenders will be issued in which a composite solution and a prestressed concrete solution will compete directly.

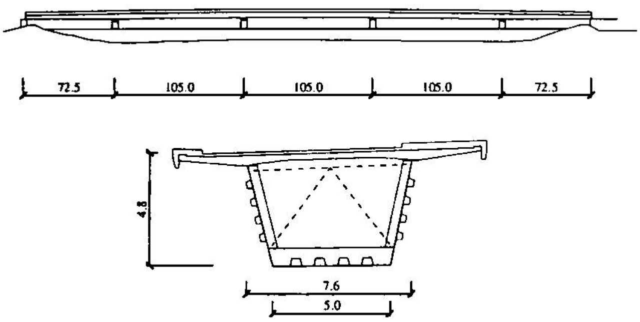

Figure 2: Pöchlarn Bridge across the River Danube

The special feature of this design is the type of erection envisaged. First of all, the steel part of the cross-section will be advanced using the launching method. The concrete slab will be produced analogously by inserting the deck which is concreted section by section at the southern dam and which will only be bonded subsequently. In addition to a slight economic advantage, this construction method is expected to result in significant improvements of the quality of the deck since the fresh concrete will not be subjected to the load which cannot be prevented in conventional construction nor will squeezing due to shrinking occur. Moreover, the deck can be very easily replaced in the future.

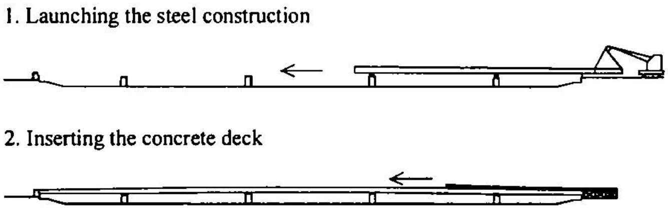

Figure 3: Construction of Pöchlarn Bridge

The bonding effect is produced by a welding seam between the top steel chord and a „Perfobondleiste“ which is inserted together with the deck and slightly protrudes over the lower edge of the deck. This protrusion makes it relatively easy to fix the bonding strip in the formwork and also functions as a lateral guide of the deck during insertion. In order to achieve a guide play, each screwed connection of the upper cross arm is fixed for insertion by means of two provisional screws with lower diameters in a slightly displaced position. After insertion, the connections are unscrewed and the top chord is advanced to the bonding strip.

Fixing the Perfobondleiste during concreting

Subsequent production of bonding

Figure 4: Details

In Vienna, there are several innovative composite bridges, such as Kaisermühlen Bridge:

Construction period:	1993 - 1994
Effective spans:	60.3 + 80.6 + 66.95 = 207.85 m
Bridge area:	approx. 830 m²

Already during the dredging of Neue Donau, two piers were constructed. At that time it was planned to re-erect the emergency bridges used for the traffic across the River Danube following the collapse of Reichsbrücke as pedestrian bridges at this site. The positions of the piers were adjusted to these 80 m long one-span girders. After this plan was dropped, the position of the piers still was a binding condition for the design of the bridge. The plane environment without any dominance made a significant cable-stayed bridge appear to be a particularly desirable solution. However, the effective span length ratios were very unfavourable for this approach. Instead of guying a specific centre span back to the abutments, the two end spans required an elastic support in this case. As a result, the longitudinal girder of the centre span was stiffened with a triangular truss structure which is harmoniously integrated into the room created by the gradient ascending to the centre. Thus, the non-rigid end spans are elastically stabilised against the stiffened centre of the bridge via bundles of three cables each.

The pylons are rigidly connected to the structure; due to this restraint and the widening of the cross-section in both directions, there was no need for an upper cross arm for stabilisation purposes. The longitudinal girder is formed by two plain girders placed in an inclined arrangement to each other so that the width of the pedestrian level of 4 m visually widens to the top. The footway construction consists of a ribbed concrete slab with trapezoidal sheeting as permanent formwork.

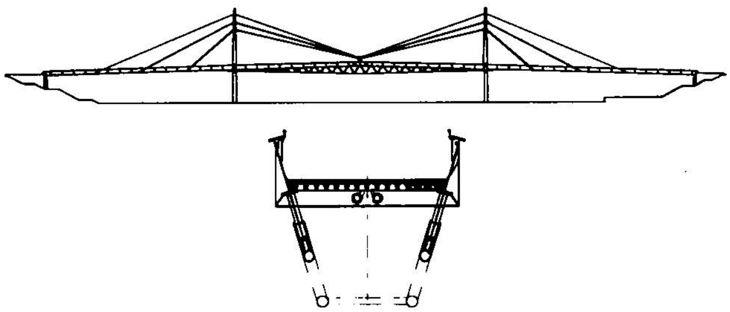

Figure 5: Kaisermühlen Bridge

The supporting sections of the two end spans were welded together along the bridge axis at the mounting sites and launched via temporary frames and barges to the piers in the river. The pylons were already provisionally connected to the supporting structure via joints and launched together with it. The centre piece of the longitudinal girder was mounted to the stiffening truss in parallel to the river bank from where it was lifted by a mobile crane to two barges which transported it exactly below the two cantilevering parts of the end spans. By means of presses and strands, the centre part was lifted to the correct level of the supporting structure where it was welded to the two end spans. Finally, the pylons were folded up, rigidly welded to the longitudinal girders, the cables were partly stayed, the carriageway was concreted and the final cable tension was adjusted.

For the construction of the 20 m wide Ameis Bridge across the western railway line, a one-span structure without piers was to be designed in order to ensure a flexible arrangement of the tracks below.

Construction period:	1982 - 1983
Effective span:	58.5 m
Bridge area:	approx. 1,300 m²

Trumpet-like widenings reaching far into the bridge had to be accepted so that it was not possible to apply a trough-bridge design which had been used in the old structure to be replaced. The already low clearance profile of the railways with 5.50 m above the rail top and the gradient permitted a maximum construction height from 1.65 to 1.75 m at the span's centre as a function of the cross-section of the bridge, which was even reduced by more than 50 cm towards the abutments so that the sickle-shaped girders had a high slenderness ratio of only 1/35. For the one-span structure, the composite solution was particularly well suited since the concrete was to be placed exclusively in the compression zone. This design was clearly more economical than a steel-deck bridge with an orthotropic plate. The 30 cm thick concrete slab, which was required anyway due to the high compressive stress, also offers the advantage of being able to ensure transverse distribution alone due to its stiffness, requiring no further bracings. It was possible to keep the steel part very simple by using nine single I-shaped girders which were only structurally connected by extreme cross girders. The trumpet-shaped widenings are handled by means of two additional, slanted girders.

The concrete strength class used was B 500, as planned, and necessary enhancements were achieved by inserting compressive reinforcements. The increased mass as compared with a pure steel construction improves the vibration behaviour of the one-span structure. The option of installing a vibration absorber was envisaged, but based on subsequent measurements carried out under traffic load it turned out to be unnecessary.

The total hog of the steel girders was 60 cm, out of which 15 cm were attributable to the impact of the concrete's shrinking and creeping. Even though individual deformation components showed slight deviations from the calculated values during construction, the aggregate deformation was still estimated correctly. The main girders received a field connection approximately in the centre of the bridge where it was possible to set up a temporary frame between the tracks. The girder components with a length of up to 32 m were transported to the site by night and placed using a two-engine rubber-mounted crane. The webs were connected by high-strength, friction grip bolts, and the chords were welded on site with the lower chords being made of Alfort steel with a thickness of 90 mm.

3. Nordbrücke

3.1 Rehabilitation of Nordbrücke

Nordbrücke which was completed in 1964 has with 2 x 2 lanes and follows the north-west railway line which was abandoned due to revised plans for Vienna's railway network.

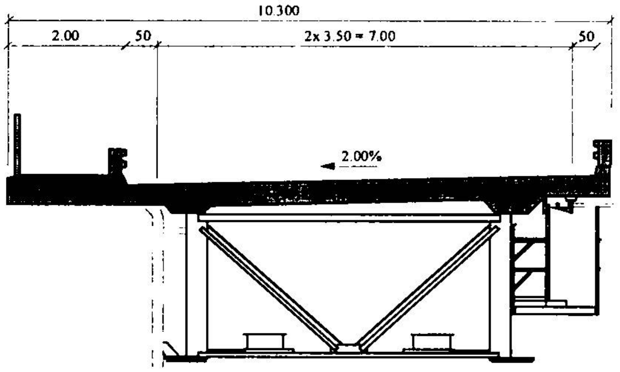

Figure 6: Cross-section of Nordbrücke

This bridge across the Danube was erected in composite steel construction – for the first time in Vienna – with a total of four plain main girders made of steel St 52 with a height of 2.60 m and a span of 83 m. The supporting steel structure was assembled at the right bridge head and launched across the railway facilities and the River Danube towards the left bank. In the years 1984 and 1985, a ramp which already branches off on Nordbrücke was annexed to the composite structure. In this process, the existing cross-section was supplemented by another main girder. Taking into account the creeping of concrete, the achievement of the bonding impact and the connection to the old concrete carriageway deck were timed in such a way that the 30 cm wide connecting joint remained virtually stress-free during concreting.

With its current peak traffic load of up to some 108,000 vehicles per day and, above all, with its maximum load of 2,310 vehicles per lane and hour, this structure is among the bridges with the highest load in Central Europe. After more than 30 years of bearing high traffic loads, the resulting state of the bridge required the performance of the first general rehabilitation. The damage to the deck is largely attributable to de-icing salt whose impact was still unknown at the time when the bridge was constructed. Other systematic damage was caused by the ageing of the bituminous water-proofing and by the omission of the insulation below the central strip and the pedestrian area, which used to be common practice for economical reasons at that time. This damage was monitored and documented in the on-going inspections of MA 29 and, eventually, recorded in a summary assessment which formed the basis for the decision in favour of general repair works.

After the removal of the entire bridge equipment, bituminous surfacing and old water-proofing, the concrete located at the raw structure was repaired and covered by epoxy resin before the new, double-flamed bituminous water-proofing, a levelling course and 2 x 3.5 cm of mastic asphalt were applied.

As pedestrian and bicycle traffic was moved to Nordsteg, the narrow pavements on Nordbrücke were no longer needed. Thus, it was possible to establish one narrow lay-by in addition to the two lanes per direction, without widening the bridge in total, which would have been impossible or at least highly expensive for static reasons. This yielded a considerable increase in traffic safety and a reduced frequency of traffic jams.

For this purpose it was necessary to remove the old footway cantilever and to mount a margin protection in the form of an 80 cm high safety wall at the outer end of the cantilever arm. For the reason of weight alone, the structure was made of steel and consists of steel posts placed at intervals of 4 m to which 8 mm thick wall sheets are screwed. Additionally, a handrail is mounted on them which supports the safety wall in case of accidents as a continuous tieback. The anchorage of the wall posts at the top of the cantilever slab was designed for a static impact force of 100 kN. In order to produce the anchorage, first of all, the outermost 50 cm of the cantilever slabs were removed by means of high-pressure water jets and the reinforcement was uncovered. Additionally, slots were cut, also by means of high-pressure water, for a strong, upper secondary reinforcement concentrated near the posts. At the end of the cantilever arm, an edge beam was concreted which acts as a stiffener and distributes the truck wheel load required by the standards in such a favourable way that it was not necessary to enhance the reinforcement within the standard range. The outer formwork of the edge beam is formed by a continuous margin sheet at the outside of which the posts of the safety wall are mounted.

The mobile scaffolding for concreting the edge beams was conceived in such a way that the loads were introduced close to the main girder. The formwork was pressed to the existing slab by means of anchor bars. On the whole, all the re-structuring measures were designed to have no significant impact on the main system of the bridge. In relation to the overall area of the slab, the changes and additions to the cross-section are of minor importance. The prestressing of the tension zones was not affected in any way.

At its 30th anniversary, Nordbrücke is a practically new structure, furnished with lay-bys, a steel margin protection stiffening the entire concrete deck and new central strips with safety rail damping elements, all that in maintenance-friendly versions. Moreover, a convenient pedestrian link was provided by the Nordsteg replacement bridge. The costs of the general repair works amounted to approx. ATS 200.0 million. Apart from damage due to the action of de-icing salt and moisture penetration, the 30-year old composite deck does not show any cracks and fatigue problems in the bonding area and was turned practically new by the repair works. Since constructional defects were not found in the composite structure either, this bridge is again in a perfect state so that composite construction is recommendable for bridges of this type both in technical and economic terms.

3.2 The Bridge Monitoring System BRIMOS

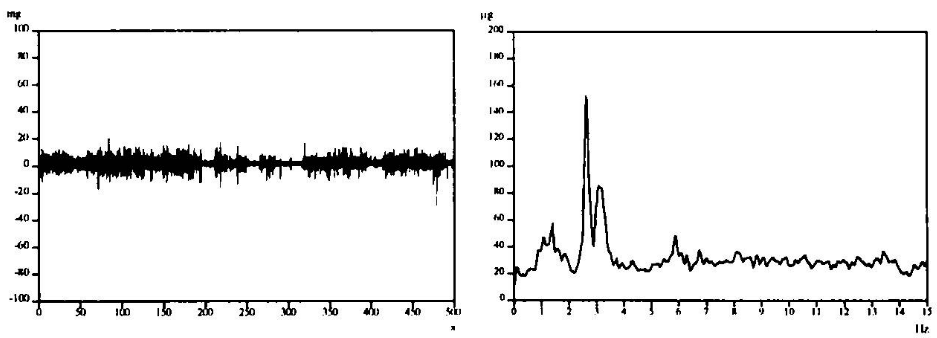

Figure 7 : Typical signal and spectrum of the Nordbrücke in Vienna (composite structure)

For the purpose of „System Identification“ a monitoring set-up was created, that enables quick an efficient recording as well as signal processing and report generation. The basis is the measurement of acceleration in a well determined layout of relevant locations of a structure. This provides data for the FFT analysis to generate the desired spectra. In addition data of the actual displacement of the structure is collected by infrared laser to gather information on the static behaviour and its relation to the dynamic action.

3.3 Data processing

The collected data are processed to provide an informative report, which shall contain information on the signals itself in the desired units, the power spectrum of the readings, raw and smoothened, the drift of the readings and the relevant displacements. In a further step the readings of the various locations are combined to get an averaged spectrum and the related displacements. This is the basis for the animation of the modes of the structure and the visualisation of it.

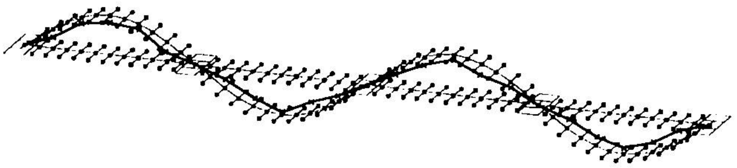

Figure 8: First mode calculated and measured of the Nordbrücke in Vienna

3.4 Conclusion

Due to the fact, that this bridge was monitored during 3 different stages, before, during and after the rehabilitation, valuable information was gained about the influence of the state of the structure on the response spectrum. From this basis it is tried to develop further tools to assess the quality of structures using data from dynamic monitoring.

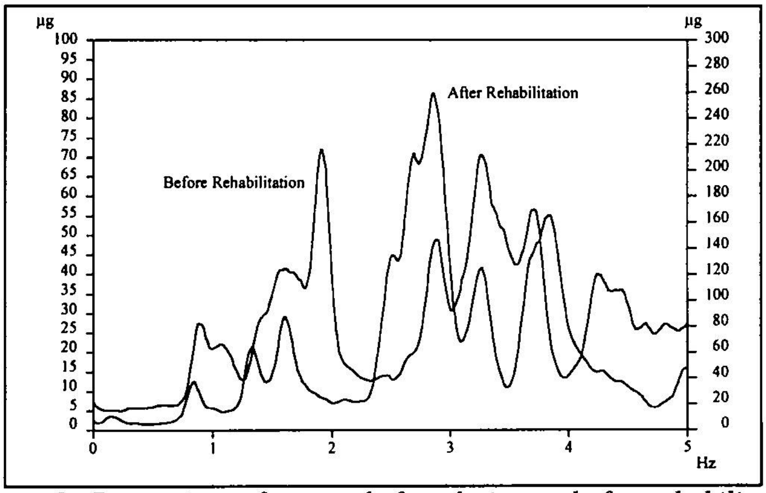

Figure 9: Comparison of spectra before during and after rehabilitaion

In future inspections will be carried out periodically to judge the state of the structure with this system. The calculation of life time cycles will be based on firm data and be more accurate. A benefit in terms of safety and allocation of funds is expected.