Paul Bonatz and the Search for an Art-Form for Motorway Bridges

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> But, only that kind of architect is able to cooperate with the engineer, who can also sense the technical.
>
> (Bonatz 1940)

Shortly after coming into power in the summer of 1933 Adolf Hitler ordered the construction of a vast motorway system for Germany, the *Reichsautobahn*. Soon it became obvious that the anticipated propagandistic effect of this project would loose much of its glance if its thousands of planned bridges lacked a proper artistic quality. To solve this problem, Paul Bonatz (1877-1956), one of the leading German architects at that time, was asked in 1934 by Fritz Todt (1891-1942), the Inspector-General for German Roads, to participate in the German motorway programme as an artistic advisor for bridge design. In the following years Bonatz developed into one of the key figures for the astonishing design standard of bridges of all kinds built for Hitler's Reichsautobahn.

Bonatz' most important act in this process was to implement in dozens of training courses a design philosophy for the engineers and architects involved in this vast project. The aesthetic approach towards the appearance of bridges that Bonatz used in this case, called "Arbeitsstil" (labour style) by Bonatz himself (Frank 1985), was mainly based on the idea of visualising the engineer's construction through a few, effective design interventions.

Just the thought that there could be any need of visualising the construction of a bridge, thus one of the building types whose appearance is already under the strongest domination of construction, may seem strange especially to engineers. In fact, this byway of construction history takes us deep into the delicate field of the relationship between engineers, who – if we follow Tom F. Peters – "are primarily process-oriented", and architects, who mainly seek "a visual statement" (Peters 1992). However Peters also states that it is the "technical thought" which connects both parties against all differences (ibid.).

It is the task of this article to show that Bonatz' working method of the "Arbeitsstil" was inspired by this "technical thought", as it focused in visualising the construction by use of the design method of tectonics. For showing the intense relation between construction and tectonics this article is going to concentrate in works by Bonatz made of reinforced concrete, as the possibilities for designing the appearance of a bridge are much broader and the architect's work can be much better analysed in this material than in steel.

SEARCHING APPROPRIATE FORMS FOR ENGINEERING STRUCTURES

After the dissolution of the old ideas about architecture forced by the strong impulse of the Modern Movement, new paradigms emerged for developing and expressing architecture. Besides the idea of *functionality* it was mainly the *construction* that moved into the focus of the conceptual thoughts of the architects. This reorientation was a consequent reaction to the multiple changes that befell the world in the *machine age*, an era that saw the breakdown of nearly every traditional value but also the triumphal rise of a new profession: the technician. In the field of building it was the civil engineer who took over the role as pacemaker of development.

It is one of the basic doctrines of nowadays' architectural history to emphasise the role of the nineteenth-century engineers' legacy as one of the most important sources for the new paradigm that was brought into architecture. This argument was already one of the main aspects in the early historiography of Modern Architecture, at least since Sigfried Giedion (1888-1968) published his Book *Space, Time and Architecture* (Cambridge, Mass., 1941). But Giedion, like most architectural historians, seemed to have overseen that engineering also developed further on *after* the godfathers of Modern Architecture like Walter Gropius (1883-1969), Ludwig Mies van der Rohe (1886-1969) or Le Corbusier (1887-1965) had taken over the architectural scene (Klotz 1986, 10). Regarding the big influence of Giedion's book, one does not have to wonder that the intense discussions among engineers and architects about the aspect of engineering structures are a more or less unknown chapter of nowadays' building history, even if they lasted throughout the whole heroic period of Modern Architecture.

Actually, the discussion about an adequate formal expression of construction already started around 1900, when neither a pure form following correct statics nor a supplementary beautification by an architect were seen any longer as promising paths to the future design of engineering structures. One of the most important forums for these discussions emerged in Germany in 1907 with the *Deutscher Werkbund*. Founded with the intention to improve the design of all sorts of common artefacts, the Werkbund paid special attention to the built environment and thus also on engineering structures from the start.

It was also in Germany where this discussion got another important boost with the so-called "Cologne bridge quarrel" of 1913, which developed after the competitions for a street bridge between Cologne and its suburb Deutz on the eastern bank of the Rhine were finished. This conflict between the bridge building company Dortmunder Union and its consulting architect Peter Behrens (1868-1940) on the one hand and M.A.N. with its consulting architect Carl Moritz (1863-1944) on the other hand, originated from the reproach that the second-round design of the latter was a copy of the first-round design of the former. This incident got its importance by the fact that all expert opinions (no matter if they were delivered by engineers, architects or lawyers) classified both bridge designs for the first time officially as *works of art* because of their delicately refined engineering structures.

Even if the legal proceeding ended in a settlement out of court, the trial itself was a milestone for future bridge design in Germany. After the First World War an intense cooperation between engineers and architects became the standard procedure for the design of important bridges. Even if we can find similar cooperations in all important bridge building nations around 1930, the German architects' approach to bridge design in this time seems to be of significant difference. While, for example, most of the consulting architects in the USA still stuck to the late nineteenth-century principle of *architectural treatment* of bridge components, as abutments, piers or towers, the German architects were normally involved in the whole design process and tried to reach an appearance that corresponded with the sober character of an engineering structure.

Early Designs for Engineering Structures by Paul Bonatz

Therefore, when Bonatz started his work on the Reichsautobahn in 1934, the idea of expressing artistic aims through a design appropriate to the engineer's construction itself was already a widespread attitude among German consulting architects. But their methods still notedly differed and did not show a clear concept for reaching the goal of creating a clear and common language for the appearance of engineering structures. Masses of articles and several books on bridge aesthetics were published, only to show a big confusion about finding the right way.

Bonatz himself was already quite active in the field of consulting engineers since the middle of the 1920s. Especially his work on the barrages of the Neckar River attracted widespread attention that also reached foreign countries, as it formed one of the essential parts in an exhibition about German architecture that took place in London's Architectural Association in 1928 **(Fig.1)**. He furthermore showed interest in the design of bridges as he not only cooperated in several competitions with some of the most important German bridge building companies, but also was involved in the erection of some chief works of German bridge engineering of those years. One of these projects, the bridge over the Lech River at Augsburg-Hochzoll, can be seen as a paradigmatic work for the trend of extreme reduction of design features in German bridge building of the 1920s.

The supporting construction, erected by the company Wayss & Freytag after the ideas of the engineer Oskar Muy (active around 1913-64), was formed by four hollow-box three-hinged arch ribs in reinforced concrete. The arch ribs, spanning more than 80 metres, showed an unusual slight rise of only 8.15 metres, making the bridge one of the outstanding examples of its time. But, besides the obvious fact of giving the impression of an arch bridge, the aspect of the building did not give any hints about the used construction. To get a slight idea of the structural principle only was possible under the soffit, as here the several ribs that formed the arch were partly visible. The rest of the building instead seemed like a big solid sculpture where some giant craftsman millcutted a few deepenings for making the passage possible. Thus the thought of creating a figure appropriate to the engineer's construction in this bridge was clearly dominated by the idea of pureness in form but not of explaining the construction **(Fig.2)**.

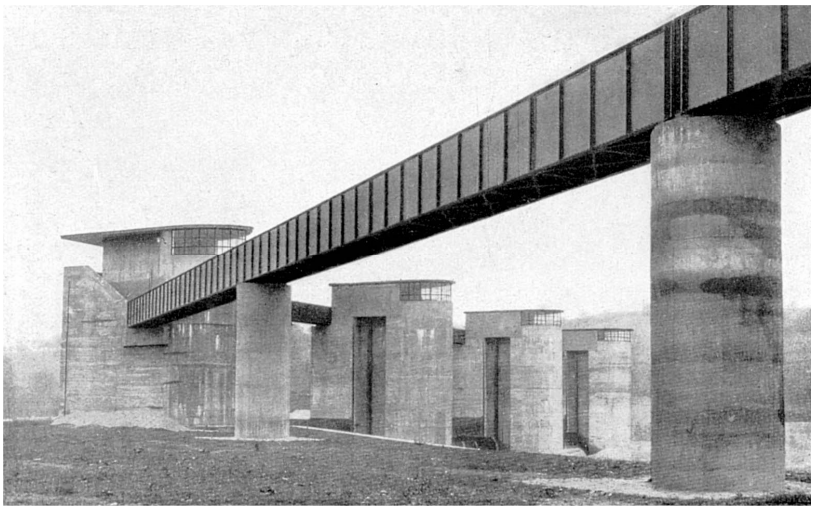

Figure 1. Paul Bonatz (architect), Neckar barrage at Horkheim, 1927-29 (Graubner 1931, p. 24)

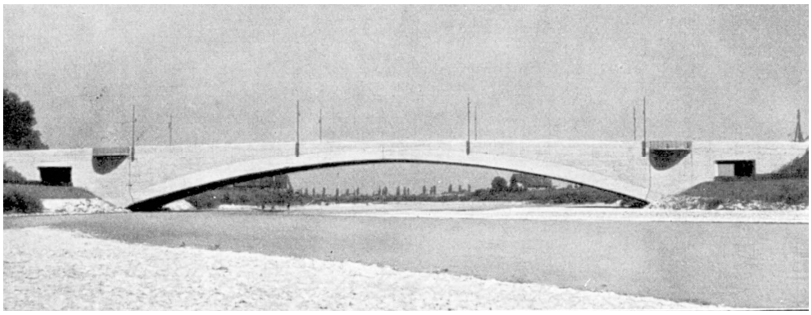

Figure 2. Paul Bonatz (architect), *Lechbrücke Augsburg-Hochzoll*, 1927/28 (Mörsch 1933, p. 381)

RETHINKING THE MOTORWAY OVERPASS

In the bridge over the Lech River Bonatz shows a manner that is typical for the tendency in bridge design in Germany at the time around 1930 (and that leads in steel bridge design to the clear preference for plate girders over trusses). But this very sculptural approach did not seem to be an adequate working method for the mission that awaited Bonatz a few years later, when he was asked by Fritz Todt to become his consulting architect for the bridges of the Reichsautobahn.

Todt's reason for employing an architect was based on a deep frustration over the appearance of the overpasses on the first section of the Reichsautobahn between Frankfurt and Darmstadt. These bridges had to be commenced in a hustle, as Hitler ordered the works on the motorway project to be started only a few months after he had come to power. So the engineers of the main construction

supervision office (OBK) in Frankfurt, all of them coming originally from the German railway authority, designed the overpasses together with local firms not only in different systems but also in the same simple manner as they had done before with minor underpasses on the railway lines. In fact, the overpasses, spanning only over a moderate distance, were not spectacular constructions at all. But for Todt it soon was obvious that they would play a key role for the perception of the whole motorway project as the concept of grade separation called for such bridges on an average interval of 800 metres. In addition, the overpasses were the only built structures that could be seen by the drivers as the bigger, much more ambitious bridges were hidden under the road's surface.

Bonatz' first task was to write an article for the first issue of Todt's freshly founded magazine "Die Strasse" (the road) that was planned to become the propagandistic centrepiece of the motorway project. In this article Bonatz presented three basic principles for the overpasses:

> […] as little remarkable as possible
> as few mass as possible and
> as much forward sight and field of view as possible.
>
> (Bonatz 1934, p. 14)

Thus Bonatz here demanded the realisation of a constructionally optimised aesthetics of "growing boldness and airiness" (Bonatz 1934, p. 15), like he had established it already in several bridge designs short before, as, for instance, in the Bridge over the Neckar canal harbour in Heilbronn **(Fig.3)**.

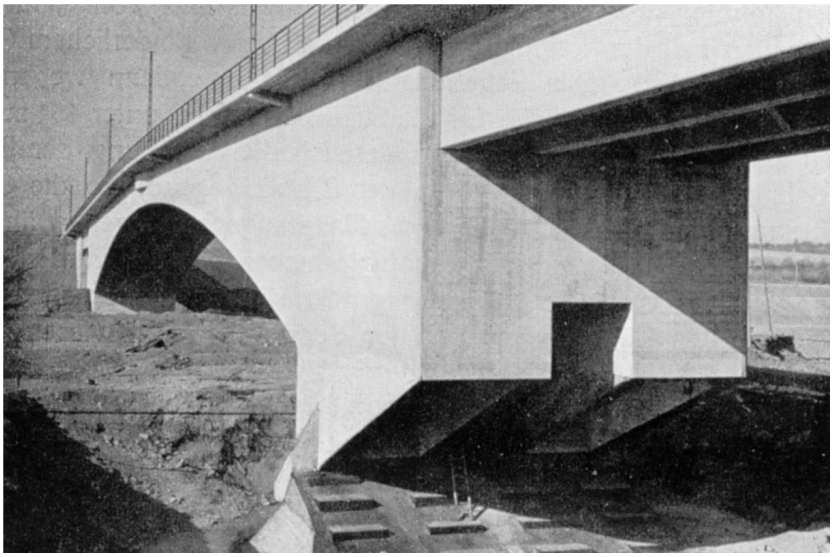

Figure 3. Paul Bonatz (architect), *Kanalhafenbrücke Heilbronn*, 1930-32 (Mörsch 1933, p. 516)

In order to avoid the cacophony of different overpass types, as it had been produced on the first section of the Reichsautobahn, Bonatz emphasised also the importance of standardisation for the overpasses, in order to achieve "a series-like togetherness" in the different sections (Bonatz 1934, 14). But, besides all engineer-like rationality, a reference to regional aspects remained of great importance to him:

> By no means will the same type be used uniformly in the whole of Germany. In the mountains these bridges will look different than in the plain. On rock they will have another expression than on sand.
>
> (Bonatz 1934, p. 14)

In the following part Bonatz discussed basic design possibilities for overpasses, remarking that the "accentuation of the functions" and thus the illustration of the "struggle of the forces" represented for him the basis in the design of engineering structures (Bonatz 1934, p. 15). Bonatz also paid certain attention to the central support that was reasonable for girders in reinforced concrete due to the 5 metres broad centre strip. Although this element established pretty uncommon bridges with two openings, Bonatz pointed out that therein could also be the possibility to develop a new bridge form. Therefore Bonatz presented not only four basic forms of overpasses, but afterwards also discussed by means of five examples some good and bad solutions for the junction of the central support with the superstructure.

His four basic overpass types consisted of two examples with clearly pronounced abutments that were slightly set off against the edge of the roadway. One of them showed two-hinged frames with hinged supports in the centre (A), the other one a beam that was firmly fixed above the clamped central pillar (B). The other two basic types came with four openings. One being a continuous beam on three clamped supporting piers (C), the other one a rigid frame construction that was articulated at the bases **(Fig.4)**. The fundamental characteristics of all four schemes were railings and protruded sidewalks that reached also over the abutments, a slightly curved alignment in the longitudinal section and a treatment of the supports that was appropriate to each bridge type, since this was for Bonatz "of crucial importance" (Bonatz 1934, p. 18)

Four positive examples for the design of the central supports (E, F, G, H) demonstrated in comparison to a counter-example (J) a further important work method of Bonatz **(Fig.5)**. It was the intensification of already existing contrasts between the structural elements "to give an animated expression to the transition from support to load." (Bonatz 1934, p. 18)

As we can learn from the third issue of Die Strasse, it seems that the article provoked some expressions of displeasure from the engineers, most of them referring particularly to a somewhat diffused description of the static system of the example A. Since such criticism could have led to substantial doubts about the expert knowledge of the designated supreme bridge designer of the

Reichsautobahn, Todt necessarily had to respond to it. His reaction was extremely smart, because Die Strasse published a statement of Emil Mörsch (1872-1950), who was an unquestioned authority in the area of reinforced concrete in this time in Germany. Mörsch first stressed his deep knowledge of the objectionable project by mentioning that it was compiled by the company Wayss & Freytag under his supervision, in order to defend thereupon Bonatz in all points of attack (Mörsch 1934).

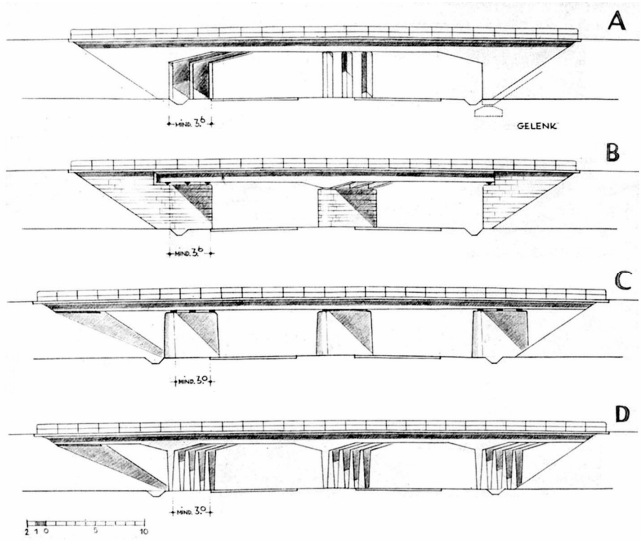

Figure 4. Paul Bonatz, Basic types for motorway overpasses, 1934 (Bonatz 1934, p. 15)

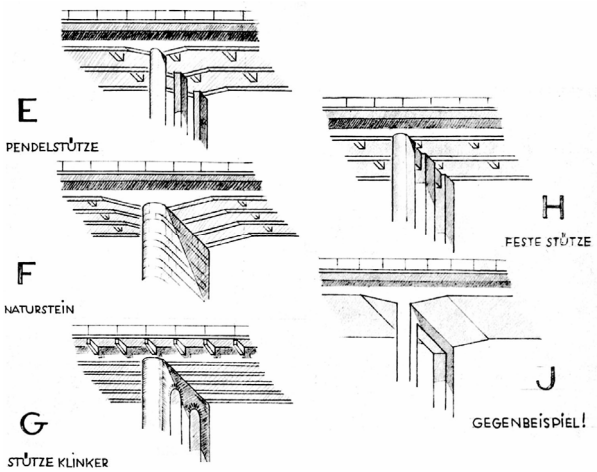

Figure 5. Paul Bonatz, Basic types for junctions between beams and supports, 1934 (Bonatz 1934, p. 16-7)

Being under the protection of Mörsch in a technical view meant that no further criticism about Bonatz' theses arose. In fact, Bonatz' thoughts even were endorsed by Karl Schaechterle (1879-1971) of Stuttgart, the engineer who would become the central figure for bridge engineering of the Reichsautobahn in the following years. Together with his young assistant Fritz Leonhardt (1909-1999), Schaechterle fully backed Bonatz' theses in another article about motorway overpass design, which just a few months later was also published in Die Strasse (Schaechterle and Leonhardt 1934).

The Design of Overpasses on Other Motorways

For understanding the relevance of Bonatz' approach of using the visualisation of the construction as design principle for overpasses it is necessary to have a short look to the forms of edifices of this type in Italy and the USA, the only two other countries that also possessed motorway-like roads at the beginning of the 1930s. The *Autostrada dei Laghi* (1923-25), built for connecting Milan with the lakes in northern Italy, was the first extensive project in Europe of an automobile road that showed grade separation over the whole distance. Even if its overpasses, due to a road width of only 8 metres, did not need any supporting structures in their centre, we still can compare the different design philosophies of this overpasses and the proposals of Bonatz for the Reichsautobahn. Framed by wing walls nearly rectangular to the surpassing road, the sparsely subdivided structure in reinforced concrete reminds us of the reduced forms of Bonatz' Lech Bridge, though its unharmonious expression can't be called artistic at all **(Fig.6)**.

Figure 6. Overpass on the *Autostrada dei Laghi*, ca. 1924 (Livini 1984, p. 52)

Clearly designed with more ambition were the standard overpasses for the motorway between Milan and Turin (1929-32). The bridges were now showing two more openings for giving a better forward view and possessed a more sophisticated parapet. But, like the former example, these bridges, besides their rather rough appearance, did not show any artistic way of dealing with the construction. Especially the haunched junction between T-beam and support did not impart a clear idea of the static system and matched almost with Bonatz' counter-example J **(Fig.7)**.

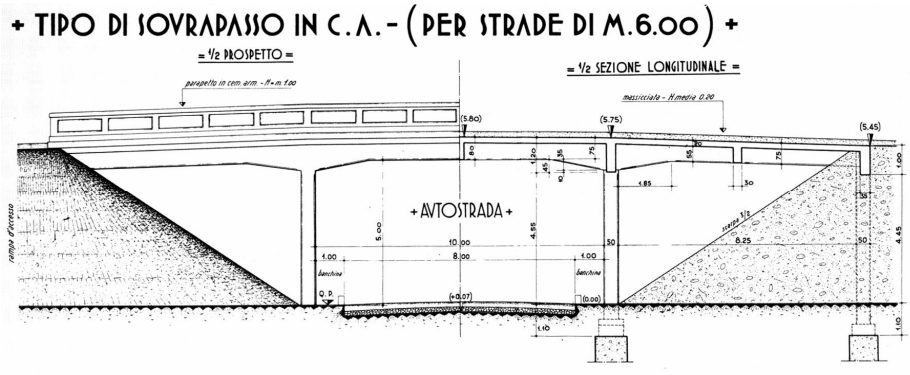

Figure 7. Standard type of overpasses on the *Autostrada Milano-Torino*, ca. 1929 (Livini 1984, p. 107)

Totally different from the pragmatic functionalism of the Italian overpasses were the bridges on the American motorway-like roads of this time. One of the most prominent examples is the *Merritt Parkway* in Connecticut, which was begun in the same year when Bonatz published his article and got finished in 1940. Similar to the Reichsautobahn, the Parkways were not only planned as expedient traffic systems but also as elements to enrich both the pleasure for the surrounding scenery and the landscape itself. Projected to become a model for the highway of the future, even the layout of the Merritt Parkway with separated two-lane roadways for both directions was nearly the same as in Germany. The only important difference was that the 6.80 metres wide centre strip was narrowed to 0.40 metres in the range of the overpasses to avoid a centre support. Nevertheless, the role of the bridges of the Merritt Parkway also was seen to be important for the perception of the whole project and thus they were designed in cooperation with an architect, George L. Dunkelberger (1891-1960) **(Fig.8)**.

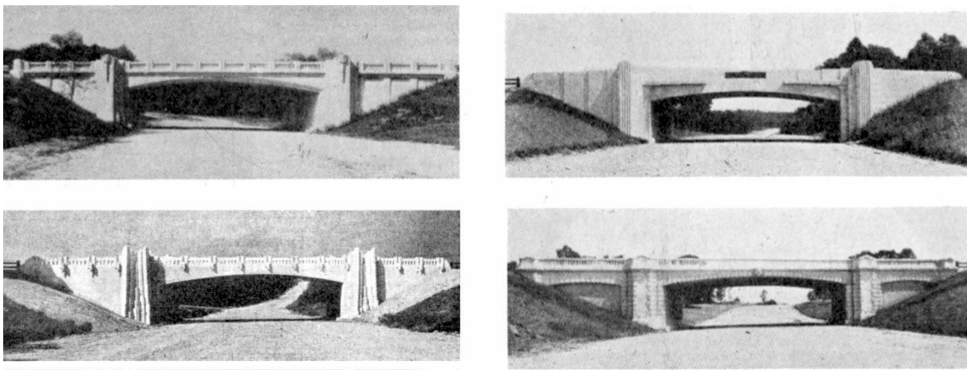

Figure 8. George L. Dunkelberger (architect), Overpasses on Merritt Parkway, ca. 1937 (Sumner 1938, 397-8)

Compared to Bonatz' drafts, Dunkelberger's different attitude towards the design of engineering structures is more than obvious. In spite of the use of merely standardised rigid frame constructions,

each of the 70 overpasses of the Merritt Parkway got its own, extremely elaborated appearance. By doing so, Dunkelberger's designs did not care about the construction of the edifices at all. Therefore his work, though showing some up-to-date Art Deco forms in some of the overpasses, still belonged to the tradition of the nineteenth century, when the *architectural treatment* of bridges was seen to be totally independent from the engineer's structure.

Looking for Solutions for the Reichsautobahn Overpasses

Coming back to the work of Paul Bonatz, we discover that also in Germany things did not develop immediately as well as expected and Todt had to turn to Bonatz again. After a visit to the nearly completed section between Frankfurt and Darmstadt Todt wrote to Bonatz at the beginning of 1935 that he was "shaken to the core by the bad architectural appearance of the numerous bridges, which now are spanning over the roadway" (BA Bln, R 4601/1489) **(Fig.9)**. In order to finally get rid of the problem with the overpasses, Todt suggested that Bonatz should provide a report about the buildings of this section, which could serve as future assistance for the OBK:

> With your excellent way to treat the things, it surely will be possible to help essentially and not to raise at all a feeling of annoyance about the criticism.
>
> (ibid.)

In fact the former civil engineer Todt seemed to be very anxious about the reactions of his engineers towards criticism from an architect, even if the situation of the overpasses was not everywhere as devastating as in Frankfurt. In particular the bridge department of the OBK in Stuttgart under the direction of Karl Schaechterle already had to offer some satisfying solutions for overpass structures. Especially Fritz Leonhardt's experimental steel constructions, like his overpass at Jungingen, achieved with their light decks in a cellular construction (that later would be known as orthotropic slab) a slimness that so far was hardly known (Leonhardt 1998, pp. 54-5).

As the solutions for steel bridges by the OBK Stuttgart were also seen by Bonatz to be absolutely satisfying (HStA Wi 485/396, p. 8), he only concentrated in overpasses made in reinforced concrete. But Todt still seemed to be insecure about the reaction of the engineers in the different OBK. Even if Bonatz' report was only delivered in 20 copies at the beginning of April 1935, Todt tried to point out in his foreword that it was not the goal of this expertise to show the engineers a sole path for bridge design:

> I know that two architects rarely are of the same opinion. It is the objective of this expertise, by means of a consistent point of view, to give an accomplished form also to the subordinated buildings. The expertise regards the suggested solution not as the only one, but as one of the possible good solutions.
>
> (HstA Wi 485/396, p. 51)

In the following we will take a look to the contents of this "Report about the overpasses over the Reichsautobahn on the section Frankfurt (Main) – Darmstadt" (HStA Wi 485/396, pp. 7-28), of which the architect Friedrich Tamms (1904-1980), who became also involved in the Reichsautobahn project in 1935, reported that Bonatz therein "[w]ith the experiences of a skilled university teacher [...] touched the sore spots, not searching for the outstanding, but the general" (Tamms 1942, p. 219).

Bonatz pointed out at the beginning that due to the time pressure during the start phase of the motorway project, it was totally normal that the first overpasses had to be a sort of experiments. The bridges on this section showed:

> Composite constructions, rigid frames in reinforced concrete, girders in reinforced concrete with and without haunches, plain and profiled, with clamped piers and with hinged pillars, through bridges, bridges with closed and opened parapet.
>
> (HStA Wi 485/396, p. 8)

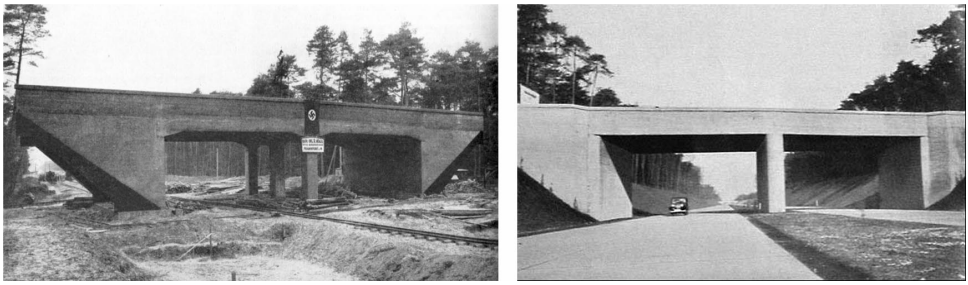

Figure 9. Overpasses *Provinzialstrasse Langen–Mörfelden* (left), 1933/34, and *Alte Mainzerstrasse* (right), 1933, on the Reichsautobahn section Frankfurt–Darmstadt (Leidner 1934, p. 354-5)

Consequently Bonatz, different from Dunkelberger's method in the Merritt Parkway, saw his task in choosing the characteristic types from this multitude as in his opinion the same conditions should naturally lead to the same forms and then to develop them towards a better expression. Subsequently he started with an analysis of 12 different overpasses that had been built on the 21.3 km long section. Out of these cases we will take a look at the overpass Alte Mainzerstrasse close to Frankfurt in km 0.316 as Bonatz' work method can be shown very clear in this example.

The actually built double-span beam bridge was formed by a composite construction made of Peiner girders enclosed in concrete and crossed the motorway with an angle of 77 degrees. Its sidewalk's soffits were lifted 0.30 metres against the main deck and coronated by a massive parapet **(Figs.9 and 10)**. While the continuous superstructure seemed to melt together with the strong central pier, it was positioned at both sides on bearing seats that were only expressed by short joints at the junctions.

Bonatz' suggestions for improvement of the edifice respected the original construction but totally changed the appearance of the bridge **(Fig.10)**. Like a surgeon, he took out the single elements of the overpass at their seams and put them together again in such a way that every element's function was visible. A light iron railing and the cantilevered sidewalk marked the position of the deck, the bearing seats and the pier were clearly contrasted to the horizontality of the loading beam.

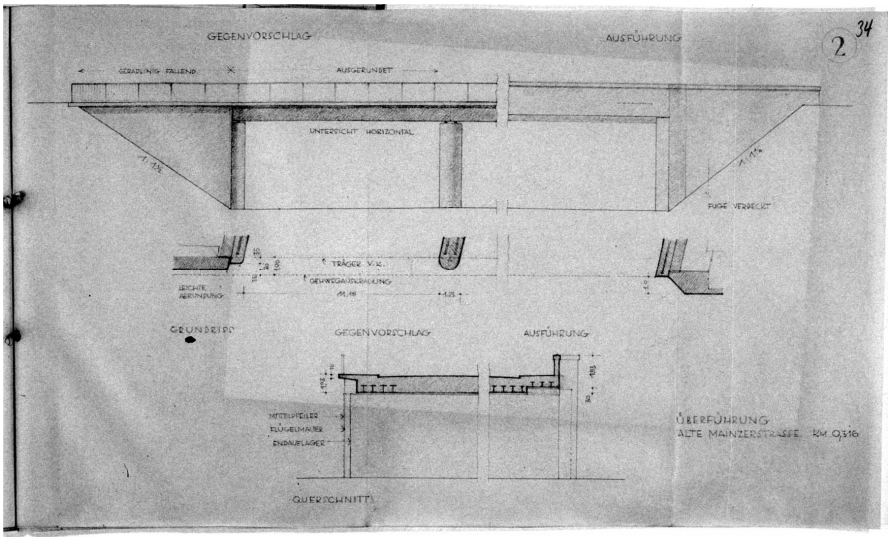

Figure 10. Paul Bonatz, Suggested improvement (left) and actual state (right) of the overpass Alte Mainzerstrasse on the Reichsautobahn near Frankfurt, 1935 (HStA Wi, 485/396, p. 34)

Subsequent to the completion of the expertise, Bonatz did not only publish another article about the other subordinated structures of the motorway, the underpasses (Bonatz 1935), but also started to organise extensive training courses for all 15 OBK together with Karl Schaechterle and Friedrich Tamms. Different from his first attempts, Bonatz' efforts now showed much more success as is illustrated here by two examples of average subordinated bridges out of the region of Dresden from the following years **(Fig.11).** Combined and contrasted with facings out of regional stones all main constructive elements were expressed sharply in both edifices. Though mainly standardised, the bridges differed in their details (here for example the junctions between girder and abutment). With a great range of variance in the different sections of the Reichsautobahn nearly all bridges now followed Bonatz' ideas for improving the visibility of the construction in the sense of what he pointed out 15 years later in his memoirs:

> "By beauty today we understand no more the attached, but the purity and intelligibility of form, the obviousness of the play of forces, the differentiation of heavy and light, of loading or hovering, in brief the expressiveness."
>
> (Bonatz 1950, p. 165)

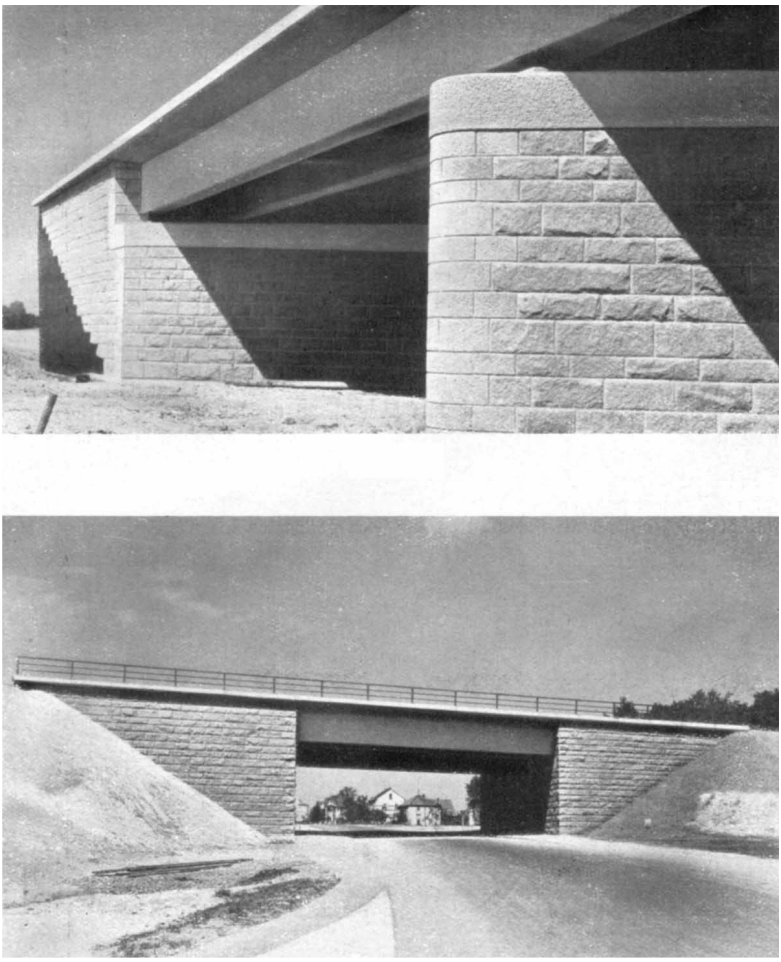

Figure 11. Solutions for an overpass and an underpass from the OBK Dresden, ca. 1938 (Buschmann 1939, p. 25)

TECTONICS – THE ARTISTIC EXPRESSION OF CONSTRUCTION

The design technique used by Bonatz in his work for the bridges of the Reichsautobahn shows clear similarities with contemporary developments in Modern Architecture, where, different from earlier times, the construction itself – by emphasising the significance of its tectonic principles – increasingly moved into the focus of the architect's artistic aims. The debate about this phenomenon of *tectonics* occurred in Germany already in the middle of the nineteenth century. It was started by Karl Boetticher (1806-1889), who differentiated by means of the Greek temples between *Kernform* (core-form), i.e. the constructive parts themselves, and *Kunstform* (art-form), i.e. the illustration of their function (Frampton 1993, 87).

It lasted until the rise of the Modern Movement till tectonics, called the "poetics of construction" by Kenneth Frampton (Frampton 1993, 2), took over the role of ornamentation in architecture. However, the awareness of its significance somehow nearly got lost in architectural history, maybe because of the great importance that was given to the aspect of functionality. Nevertheless, authors like Julius Posener (1904-1996) finally rediscovered in Modern Architecture that “the construction, which works, is not always the construction, which one can see." (Klotz 1986, 28). Posener realised this phenomenon through the analysis of facades of Mies van der Rohe’s later buildings. These buildings also stood in the focus of Eduard Sekler’s key essay about the intense relationship between "Structure, Construction, Tectonics" (Sekler 1965).

Sekler saw tectonics as the visual expression of construction which itself had to be understood as a particular physical manifestation of the “intangible concept” defined by the structure of an edifice (Sekler 1965, p. 92). Regarding this definition one easily can see that tectonics should have played an important role especially for bridges – as structure and construction always are the two dominant parameters for their design. But, neither Sekler mentioned engineering structures in his text nor did 30 years later Kenneth Frampton, whose widely recognised book about the “Tectonic Culture” in modern time’s building brought back the idea of tectonics to the world of architectural history (Frampton 1993). Hence, in the end, both also followed the reduced path that had been laid out earlier by Sigfried Giedion.

Tectonics and Construction in Engineering – a Complicated Relationship

The fact that architectural theoreticians seemed to ignore the efforts of architects like Paul Bonatz to transfer the idea of tectonics into structural engineering finds a sort of parallel in the engineer’s view. Even if architects consulted engineers in bridge building throughout the whole twentieth century, the idealistic concept that structurally optimised edifices as bridges do not need any tectonic treatment at all was a widespread thought.

A fascinating case in this field is the comparison of the bridge over the Danube at Leipheim on the Reichsautobahn between Stuttgart and Munich **(Fig.12),** designed by Karl Schaechterle, Wayss & Freytag and Bonatz, with the contemporary bridge over the Arve at Vessy **(Fig.13)** by one of the most outstanding engineers of the twentieth century, Robert Maillart (1872-1940). The comparison of these two bridges (both were based on Maillart’s structural concept for three-hinged arch bridges) recently was discussed by David P. Billington (Billington 1997, p. 219-20) and originates in an essay that Maillart himself published in 1938 (Maillart 1938).

But, while Maillart’s biographer Billington mainly came to the conclusion that the bridge over the Danube stood symptomatic for a German tendency towards a massive appearance, Maillart himself stressed to have worked with a different approach than did Schaechterle and Bonatz (ibid., p. 292). In fact, the difference between an economically optimised bridge in a side valley of the mountains

and one that was part of a monumental *Gesamtkunstwerk* played an important role for the discrepancy in the appearances of the buildings.

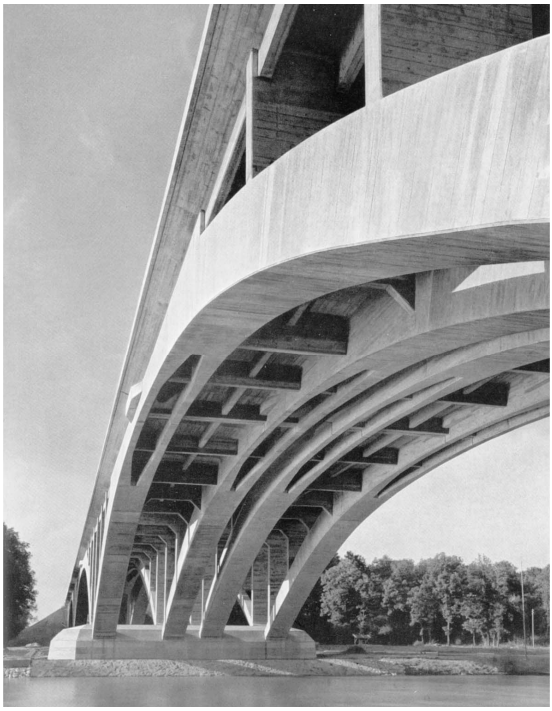

Figure 12. Paul Bonatz (architect), *Donaubrücke* at Leipheim, 1934/35 (Bonatz 1957, p. 71)

Figure 13. Robert Maillart, Bridge over the Arve River at Vessy, 1934-36 (Bill 1949, p. 119)

The constantly bended arch at Leipheim made one of the main differences for Maillart, as he used a statically optimised broken arch at Vessy. Nevertheless, Maillart had to admit that he himself also tended to use the constantly bended arch because of its beauty in his former bridges (Maillart 1938, 292). Surprisingly, in his bridge over the Arve Maillart used some tectonic elements like the protruded ends of the arch or the deck, but all in all the different elements seemed to belong to the same system, thus following the logic of Maillart's integrative static system. Bonatz' tectonic design presents instead arch, spandrel piers and deck girders in different layers. Thus he separated the elements for showing their different tasks in the system like he already had done in his overpasses.

CONCLUSION

In fact the bridge at Leipheim showed one the main problems of tectonic design. Following the idea that every single element in a construction also has a clear task corresponded to a structure of post and lintel as it was preferred by the architects of the Modern Movement. As a result the tectonic treatment that fitted for simple beam bridges or a classical arch bridge like the famous Reichsautobahn bridge over the Devil's Valley **(Fig.14)** had to fail for a bridge that followed the complex statics of Maillart.

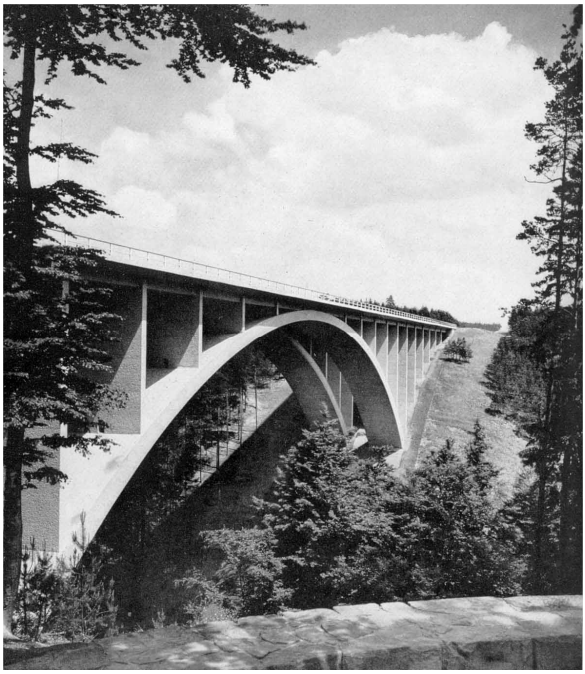

Figure 14. Paul Bonatz (architect), *Teufelstalbrücke* near Hermsdorf, 1936-38
(Bonatz and Leonhardt 1951, p. 82)

Nevertheless, Bonatz' contribution to the design of the bridges of the Reichsautobahn has to be considered as outstanding. In addition, it should not be forgotten that he was working under a dictatorship that expressed in its representative architecture the quest for immortality through the monstrous classicism of Albert Speer (1905-1981) **(Fig.15)**. It was mainly Bonatz' impulse to use the construction of the Reichsautobahn bridges itself for their required representational tasks. This modern thought puts them among the few examples of exceptional edifices built in this period in Germany.

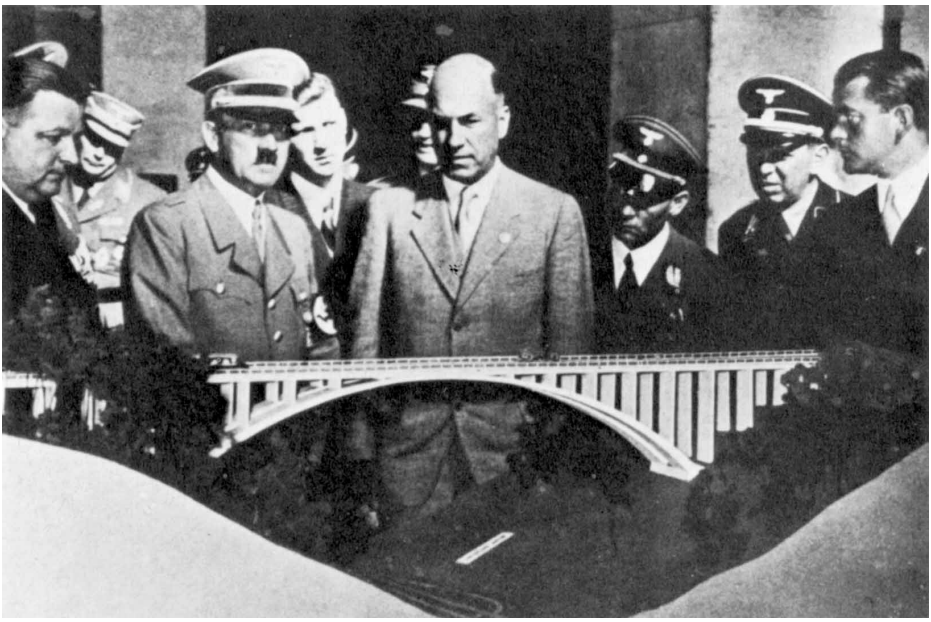

Figure 15. Adolf Hitler, Fritz Todt (centre) and Albert Speer (right) in front of the model of the bridge over the Devil's Valley, 1936 (Joachimsthaler 1981, p. 62)

Fritz Leonhardt, who always was a big admirer of Bonatz' work, pointed out in his memoirs that Bonatz "wanted to design the engineer form beautiful, by good proportions, by increasing the expression of hovering, of bearing, of the obviousness of the play of forces" (Leonhardt 1998, p. 60). As it was shown in this article, this approach towards engineering structures was based on a long tradition in Germany that had its sources in the beginnings of the twentieth century. Finally, with an intense cooperation of architects and engineers, a certain attitude in bridge design was created. This German *Sonderweg* was already perceived and appraised by the contemporaries:

> "Engineer and architect, technics and instinct will overcome the down-pulling, down-dragging, earth-born and herefrom crystallises itself the world of the future, the new culture of t e c t o n i c s."
>
> (Eckart 1928)

But in all its progressiveness regarding the formal reduction of the design, this attitude at the same time seemed to show a latent conservativism in relation to new constructions which could endanger the clarity of the appearance of a bridge.

Despite this fact, and even if most of the motorway bridges can not be valued as outstanding constructions, the comprehensive quality standard of nearly all the bridges – reaching from small culverts to gigantic viaducts – played one of the key roles for the fastly growing international enthusiasm for the German motorways in the 1930s. It was mainly the merit of Bonatz, who soon jocosely was called *Pontifex Maximus* by his co-workers, to teach the engineers and architects of the motorway project the ability to visualise the static conditions inside of their constructions. Regarding additionally his claim for a high artistic standard, Bonatz' work for the *Reichsautobahn* represents an almost unknown, but nevertheless highly interesting episode in the history of construction.

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