Iconic Form: High-Speed Railroad Structures

Figures 1 & 2: Humboldthaven Railroad Bridges at Lehrter Bahnhof - Berlin, Germany

"Railway architecture has entered its second great age. – The revival is prompted by …the advent of the high-speed trains," along with "the re-emergence of the structural engineer as a creator of station architecture" – Marcus Binney, Architectural Historian[1]

The bridges of Lehrte Railway Station in central Berlin gracefully reunite a once divided city, while forging a focal point of the modern German high-speed railway network. Initially destroyed during the division of the city for the construction of the Berlin Wall; today's bridge (Figures 1 & 2) spanning the Humboldthaven Canal, promotes a barrier free public landscape. Attached to the "reception building" (Figure 1) of the railway is a splendid achievement of function and stately architecture[2] evoked by the slender structure around. More than just a structure of function, Berlin's icon of unity represents the importance of architecture in high-speed rail (HSR) structures. Comprised of the most recent and sophisticated structural technologies, HSR bridges incorporate stringent safety aspects relating to passenger comfort and maneuverability of the train.[3] With no reference available documenting the aesthetic development and structural innovation of high-speed railroad bridges worldwide, I wish to partner with the SOM Foundation to investigate this unique field of bridge and station design.

ICONIC FORM:

Having had the opportunity to visit Berlin last summer, I noticed Lehrte Station while waiting in line to visit another monument. Contrasting the neo-classical stone buildings of the Reichstag Building, the glass arches (Figure 3) framed a sleek high-speed train as it glided across the bridge into the station. The design of

[1] Binney, Marcus (1995). *Architecture of Rail: The Way Ahead.* Academy Editions, London. p. 6
Figure 1: Photographer: Kanakaris-Wirtl, Inge (2005). *en.structurae.net*
Figure 2: Photographer: Unknown (2009). *www.hbf-berlin.de*
[2] Müller, Karlhans (1981). *The Architecture of Transport in the Federal Republic of Germany*. Heinz Moos Verlag, Munich. p. 71
[3] Introduction by editors (2009). *Track-Bridge Interaction on High-Speed Railways: Selected & Revised Papers,* Taylor & Francis Group, London. p. vii

the structure was an inspiring sight. Promoting redevelopment, the station provides access to infrastructure with an inviting character.

Figure 3: Berlin Hauptbahnhof - Lehrte Station

"In the days of the Bauhaus, the contention was voiced that engineering technology in itself was a beautiful thing. …According to (Bridge Engineer) Friedrich Tamms, this testifies to their lack of artistic talent or comprehension of aesthetics' laws."[4] Much of modern day infrastructure is "value engineered" to promote cost efficiency; adversely, this does not promote harmony between the landscape and the designed structure. Likewise, developments of social importance are monuments of culture, and exemplify our technological advancements through design. Infrastructure is ubiquitous in the developed world; yet too often lacks any consolidation with the landscape despite a completed environmental study. Railroad bridges should be no exception to architectural consideration, as they are the prominent feature of many landscapes. Justifiably, they are called on to meet objectives beyond their transportation function.[5]

HIGH-SPEED RAIL:

Governments are increasingly funding HSR projects to meet transport and "green" environmental goals. China has the most ambitious goal to spend "$300 billion in the next decade to build the world's most extensive and advanced HSR network."[6] California has ambitions proportional to China's, and is seen as the model for future interstate HSR development in the United States. Obtaining high-speeds requires straight and level tracks; aerial guide-ways, a series of piers and short-span bridges are a practical solution to maintain a level track. Commonly employed across urbanized zones, flood basins and depressions in the terrain; guide-ways represent the greatest visual impact of HSR. In a high-speed line constructed between the German cities of Mannheim and Stuttgart, the line contained 114 bridges, while only eight percent was constructed at grade.[7] With the expansion of HSR development, the need for bridges is unprecedented.

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[4] Müller, Karlhans (1981). *The Architecture of Transport in the Federal Republic of Germany*. Heinz Moos Verlag, Munich. p. 35
Figure 3: Photographer: Unknown (2009). *www.haus-hubertushoehe.de/tourism.php*
[5] Gottenmoeller, Frederick (2004). *Bridgescape: The Art of Designing Bridges,* John Wiley & Sons, Hoboken. p. 16
[6] Kuhn, Anthony (2010). *China Aims To Ride High-Speed Trains Into Future.* www.npr.org/
[7] Müller, Karlhans (1981). *The Architecture of Transport in the Federal Republic of Germany*. Heinz Moos Verlag, Munich. p. 87

Characterized by the repetitive "loading" at high-speeds, the problems encountered in the design of high-speed railway bridges are unlike traditional highway or railway bridges.[8] Vibrations resulting from the moving load relate directly to train maneuverability and passenger comfort. The textbook solution to a vibration issue would consider increasing the depth of the beam, and reducing the span's length. Although the textbook solution will provide improved performance, it does not objectively consider structural efficiency and aesthetics.

The bridge engineer is challenged with balancing structural performance, economy and aesthetics with the consequences of transforming the landscape. According to Structural Engineering Prof. David Billington, "…engineers always try to improve *performance* with no increase in cost, and often succeed." Bridge engineer Robert Maillart was different: "he also always tried to improve *appearance* with no increase in cost, and he often succeeded."[9] The design of Berlin's Lehrte Station bridges provided challenges. The design intention was to create bridges that provided maximum flexibility for the various uses presenting an organized, clean, and attractive underside in order to encourage the use of the station and the redevelopment of the area."[10] Meeting that perception, a thin concrete bridge deck atop slender steel tubing gracefully lifts the trains over the Humboldthaven Canal. In light of this aesthetic achievement, the cost of the bridge was about 10-15 percent higher than a "standard" bridge.[11] This marvel of structural engineering meets the design vision - the bridge appears to belong in the landscape, rather than dominate. "Who cares later how much the bridge has cost?"[12]

THE PASSENGER EXPERIENCE:

Success of the modern railroad is measured in passenger numbers and quality feedback, as opposed to engineering achievement. Historically, railway stations took shape during the industrial revolution of the 19th

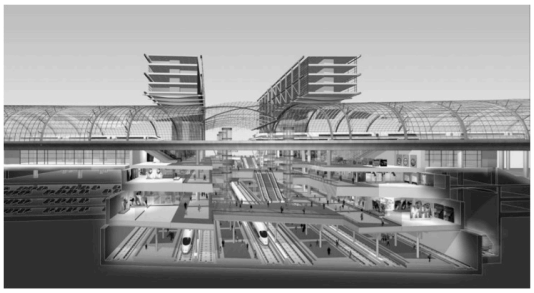

Figure 4: Cut-away of Lehrte Station

[8] Authors (2004). *Vehicle-Bridge Interaction Dynamics: With Applications to High-Speed Railways.* World Scientific, Singapore. p.xv-vi
[9] Gottenmoeller, Frederick (2004). *Bridgescape: The Art of Designing Bridges,* John Wiley & Sons, Hoboken. p. 14
[10] Ibid. p. 271
[11] Ibid. p. 273
[12] Müller, Karlhans (1981). *The Architecture of Transport in the Federal Republic of Germany*. Heinz Moos Verlag, Munich. p. 37
Figure 4: Creator: Deutsche Bahn (2005). *www.hbf-berlin.de/ - bahnverkehr2006__berlin__pk06072005.pdf*

century. Inspired by function, "'cathedrals of transport under the canopy of the railway heaven made from glass and steel' were created."[13] Entering the station from the south, a splendid view of the station is presented (Figure 4): trains above, and below shopping and dining services. Clad in a glass façade, the east-west platforms of Lehrte Station appear to float over the concourse. The long spans of the roof create a space without barriers. Like the adjoining bridges, the graceful order brought forth of slender steel tubing supports both the track and roof structures. As the entry point of the passenger experience, modern train stations are icons of the advancement of society.

PROJECT PROPOSAL:

High-speed train travel will become a reality in North America in this decade. With no reference available highlighting the combined structural and architectural innovation in HSR bridges, the SOM Fellowship will promote the investigation first-hand. Equally as impressive, modern railway stations of advanced structural splendor will be included. If awarded the fellowship, I will travel extensively documenting visits through photography and explanation. Visits will include interviewing designers of future HSR projects (schedules permitting) in North America. Overseas, research institutes conducting HSR structural research will be contacted for a visit. Distinctly, the iconic HSR bridges and stations of Eastern-Asia and Western-Europe will be visited and studied. Pertaining to seismic and geographic conditions, the countries of China and Japan in Eastern-Asia contain the most relevant bridge structures to the future California system. Most notable for excellence in architectural achievement, Western-European visits will include Belgium, France, Germany, Spain and the United Kingdom. HSR exists in countries other than those listed above, however only sites that sufficiently demonstrate the advances of HSR structural innovation and design will be visited.

My professional goal is to continue the innovation of HSR structures. Benefiting the future of HSR in North America, I will present my research to the engineering community – students and professionals alike. The opportunity to visit impressive achievements of HSR architecture in person will advance my career as a structural engineer.

[13] Ibid. p. 71