COTTON LANE GILA RIVER BRIDGE – INTEGRATION OF ENVIRONMENT AND INFRASTRUCTURE

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ABSTRACT

It is often difficult to blend the design of highway bridges with the surrounding environment. The recently constructed Cotton Lane Bridge over the Gila River at Goodyear, Arizona features a unique design that not only uses the site's natural surroundings for inspiration, but incorporates them without large scale land transformation. Primary goals for the design aesthetic included visual access to the mountain horizon and the riverine environment, as well as support for native geomorphic and biotic processes with materials, colors, and patterns. On vertical concrete surfaces, unpainted sandblast and simulated sandblast textures reveal both prehistoric and familiar desert life. The outboard face of the exterior precast, prestressed girders uses form-liners to create gecko and cactus imprints. The bridge's pier columns also feature artistic impressions of Goodyear's ecosystem, with ancient life forms such as water scorpions and dragonflies exposed by sandblasting. Patterns in the safety barrier reveal saguaro cactus, the bats that pollinate them, and a moon form. All pier columns were stained copper oxide color up to the 100 year flood elevation to suggest the wet-dry desert riparian cycle and to connect with the copper mining history of the region.

Keywords:
Aesthetics, Environment, Bridge

INTRODUCTION

Increased traffic volumes and congestion, dynamic suburban residential development, and a river habitat enhancement initiative worked together to create the need for a unique bridge across the Gila River in Maricopa county. The City of Goodyear has experienced rapid residential development in recent years. Major parts of the community were separated by the Gila River. City officials wanted to connect these areas and consolidate development on the north side of the river with a major north-south arterial that would cross the river at the foot of the Estrella Mountain formation. Maricopa County transportation officials, along with several private developers, wanted a bridge that could be constructed quickly and cost-effectively Both the developers and the sponsors of a river habitat enhancement effort wanted to make sure that bridge styling and appearance fit with outspoken local preferences for a rustic and natural appearance. Further, the City of Goodyear was concerned about how the bridge would impact their “dark sky” requirements. A unique partnership of county, city, and private developers was forged to address the varying interests and needs of each stakeholder. Using a construction management at risk (CMAR) contracting method, engineers, landscape architects, contractors, and project partners addressed these needs through unique design and construction solutions for the Cotton Lane Bridge over the Gila River.

OVERVIEW

In combination with a proposed river habitat enhancement program, hydraulic analysis indicated that a 2,100 foot long bridge was necessary to span the Gila River and properly connect with planned freeway alignments. A traffic analysis recommended an ultimate capacity of three travel lanes in each direction on the bridge. The City of Goodyear and the developers required a six-foot wide sidewalk on each side of the bridge to encourage pedestrian traffic across the river. A bridge type study revealed that traffic and hydraulic needs could be satisfied with a structure consisting of 17 spans of about 122 feet each, utilizing AASHTO Type VI modified prestressed girders. County and river improvement officials insisted that the designers use a context sensitive approach. The designers recommended that conceptual design be driven by an intensive collabaration between project sponsors, engineers, landscape architects, and contractors.

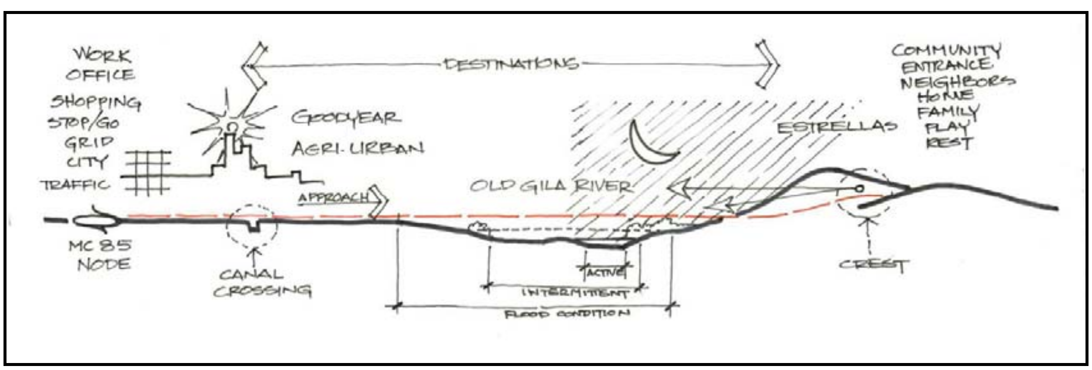

Figure 1: Context Section

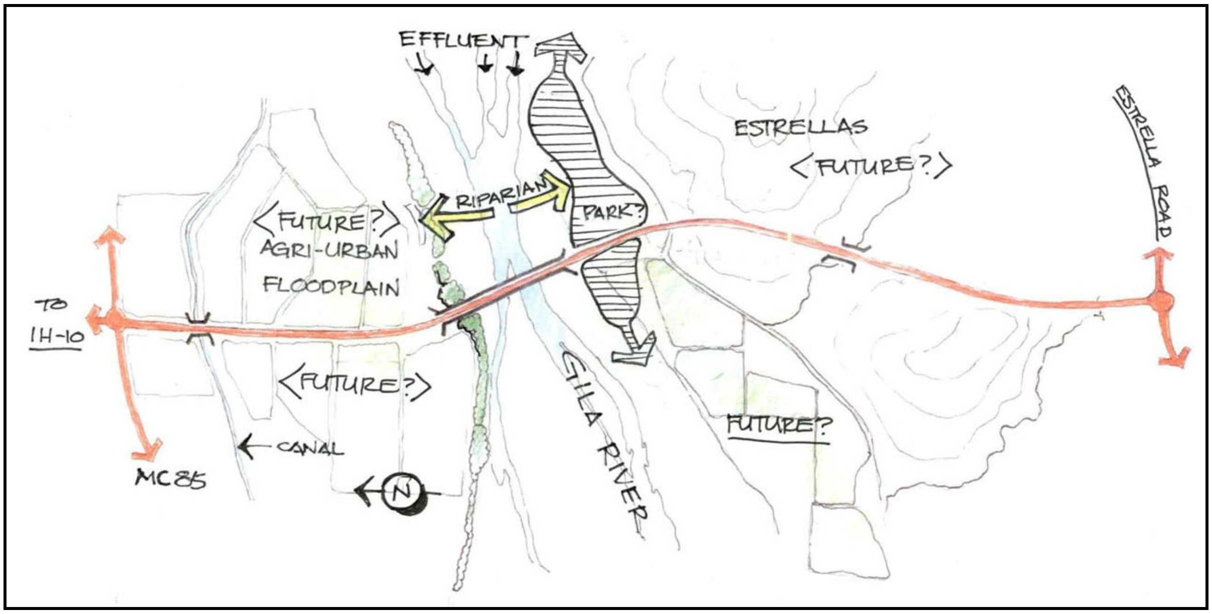

Figure 2: Context Elevation

Designers began the charrette process by conducting a graphical site analysis, which observed the various visual, geographical, cultural, and social contexts associated with the use and siting of the bridge, as can be seen in Figures 1 and 2. Fueling the conceptual design process was the idea that motorists' experience of the mountains, river, and flood plain environment in Goodyear would be shaped, in part, by the physical attributes of the bridge. The design charettes used the highly interactive process shown in Figure 3, which included high levels of participant involvement. The participants explored the various aesthetic options and conceptual themes associated with different bridge types in order to effectively blend appearance with functionality in the design. A "Rapid-viz" visualization process was used, whereby the charette facilitator conducted on-the-spot sketching in order to receive immediate feedback and alternatives from the participants.

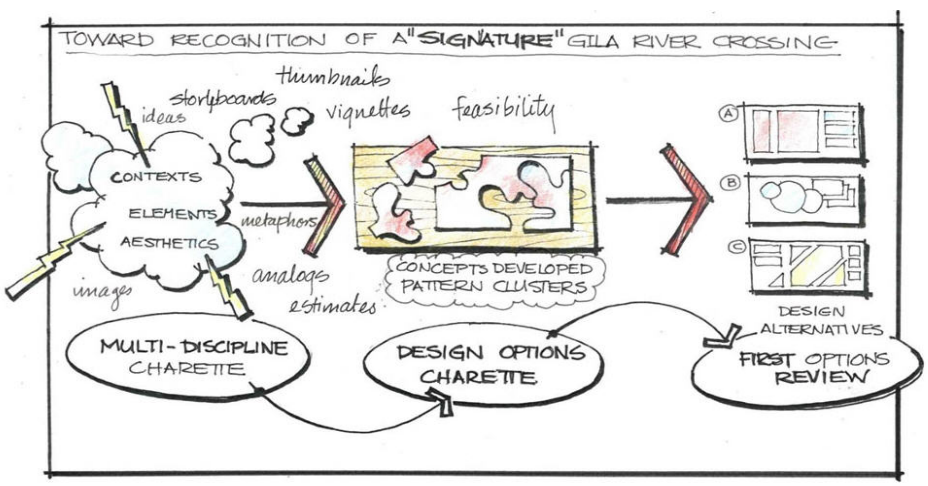

Figure 3: Concept Development Process

The Rapid-viz technique (Ref. 1) is similar to drawing short hand, using symbolic images to represent verbal ideas. It not only eliminated the designers' need for an elaborate sequence of presentation boards, but also allowed them to expedite the process of generating, assessing and refining concepts for basic structural forms and styling. It can be geared to encourage real time participations in a workshop context. Or it can be used to reduce studies and time devoted to polishing formal alternatives panels. Comments from specialists in different disciplines can be incorporated into design development instantaneously. Figures 1, 2, and 3 illustrate some of the ways that Rapid-viz was used in this project.

Since the scope and goals of the project were broad and somewhat unrestricted, the project used a CMAR contracting method, which allowed the contractor to contribute to the design process. Participation from the contractor helped to ensure that the costs, schedule and constructability were reasonable and acceptable to the project stakeholders and that design goals were feasible to construct. The CMAR process also provided greater access to the local precasters in order to determine most effective solutions.

The project was funded through a unique public/private agreement. Maricopa County Department of Transportation, the City of Goodyear, and two private developers representing the neighboring housing developments participated in financing the bridge's construction cost. Because each contributor was allowed a role in the development of design aesthetics, conflicting concerns about cost, schedule, and aesthetics arose. The design charettes allowed involvement and contribution from all participating parties, resolving many differences early in the design process.

Figure 4: Drilled Shaft Load Test per Osterberg Cell Method

In an effort to achieve cost savings without compromising any of the stakeholders' interests, the team utilized creative cost saving strategies. Precast concrete was used where possible to minimize construction time, cost, and adverse impact to the environment. Additionally, a static dilled shaft load test utilizing the Osterberg Load Cell was performed during early design as shown in Figure 4. Due to the higher reliability of the soil response obtained thru use of this load test, a reduced safety factor, as permitted by the AASHTO LRFD code (Ref. 2), was correspondingly permitted in design. Savings in the foundation far outweighed the cost of the load test and resulted in net savings of more than $1M to the project.

Through a Clean Water Act Section 404 Individual Permit (IP), which is regulated by the U.S. Corps of Army Engineers, the bridge construction project now contains 859 acres of habitat enhancement mitigation measures to off-set construction impacts to the Gila River. This IP authorized the largest amount of construction related impacts in Arizona to date. The bridge project is also linked to the Flood Control District's Rio Salado Project, a habitat enhancement and flood control project. This project will enhance over 18 miles of riparian habitat along the Gila River Corridor while providing flood protection to the Town of Buckeye. The project will also decongest the river by removing not-native plants and restoring the Gila River to its natural state.

CONTEXT SENSITIVE DESIGN

The County Transportation Engineer admonished the Design Team that what is done at this bridge crossing project would forever change the environment. He insisted that concept development be sensitive to the physical environment and biotic communities.

The design team introduced concepts of environmental and local landscape preservation early in design discussions. Dialog often centered around two questions: "How would nature build this?" and "How would nature help to achieve a desirable aesthetic result?" The charette process produced several ideas that shaped structural and aesthetic treatments. One element of the design aesthetic was inspired by the nature's own process of erosion. Stencil and sand blast techniques were used to reveal fossil-like patterns of prehistoric creatures and plants on columns. The same process was used for reveling contemporary life forms on the back of the traffic barrier, as shown in Figure 6. To achieve this weathered and eroded appearance on specially designed precast girders, designers used custom made form liners in girder production molds to reveal gecko patterns like the one shown in Figure 5. Since local aggregate was used for the cast-in-place concrete, the only paint used on the project simulated a stain that might be left on bridge piers after a major flood event originating in the upstream copper mining district.

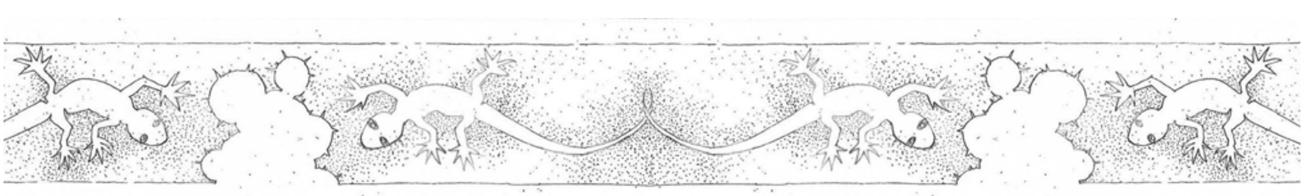

Figure 5: Preliminary Sketch of Life Forms to be Integrated within Girders

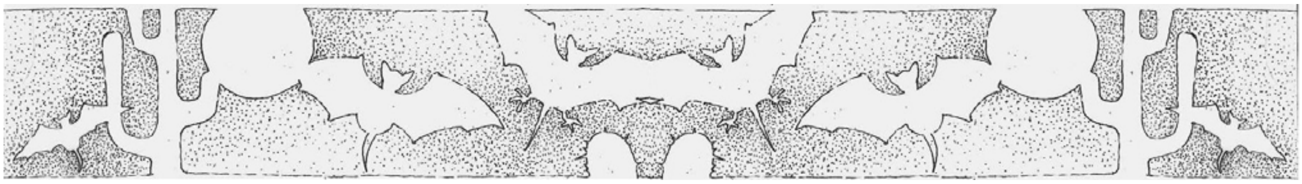

Figure 6: Preliminary Sketch of Life Forms to be Integrated within Traffic Barrier

Arizona's history is deeply connected with that of the copper mining industry in the United States. The region surrounding the Gila River, in particular, remains rich with copper today. As a means of incorporating copper into the design, a pale green shade, resembling oxidized copper, was used as an accent in many of the bridge's stains, including the railing (Figure 7) as well as the pavers off the bridge that comprise the median flatwork.

Desert storms produce sudden, often turbulent floods that can act as abrasive forces on bridges. Bridge piers were extended above the Gila's riverbed, and coated with a water-borne stain. The stain was the same pale green, oxidized copper shade as the other stained areas of the bridge.

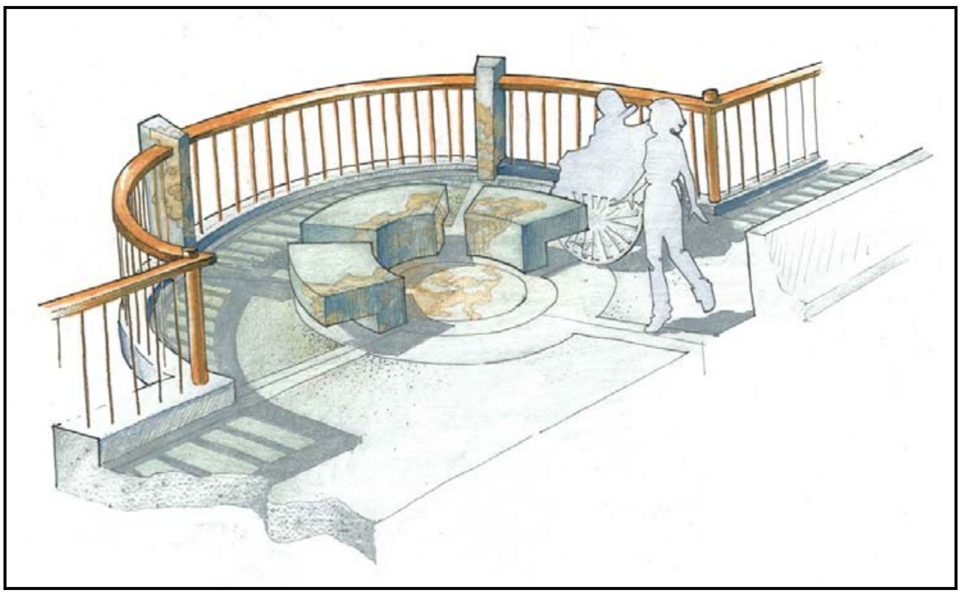

Figure 7: Preliminary Sketch of Alcove with Copper Accents in Railing

In an effort to preserve motorists' view of the Estrella Mountains, the bridge was designed to have only a slight vertical curve, with no pier structures or light poles breaking the horizon. The addition of the minimized arch required less fill than that of a flat profile, and therefore, less harmful impact to the Gila River. Shortened light poles with low-intensity lighting were used to comply with the City's light pollution and "dark sky" ordinances, providing the effect shown in Figure 8.

Figure 8: Preliminary Sketch of Bridge at Night – "Dark Sky" Requirement

The bridge's design was also driven by an awareness of the Gila's River environment. Driving at 60 mph, drivers would have almost 30 seconds of viewing time on the bridge. Designers wanted barriers that would allow motorists and pedestrians to look at the riverbed. Design of the bridge included a series of alcoves and benches, as shown in Figure 9, inviting pedestrians to gaze at the river and enjoy the natural surroundings. The versatility of precast concrete made the addition of the alcoves feasible, with the alcoves' concrete corbels serving as the false work system for the alcove slabs during construction. Pedestrian walkways were further enhanced with a design of native bats and cacti on the back face of the traffic safety barriers.

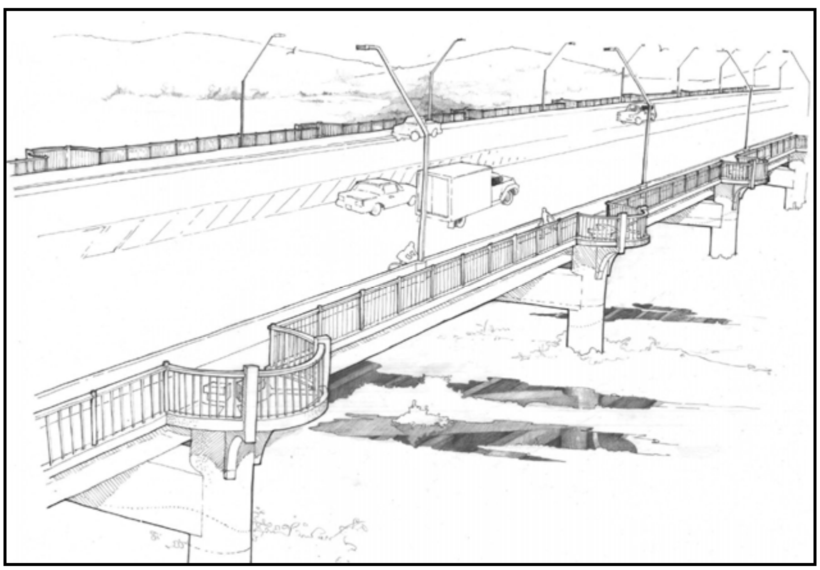

Figure 9: Preliminary Sketch of Bridge with Pedestrian Alcoves

APPLICATIONS

A relief pattern was applied to the outboard faces of the exterior precast prestressed girders in order to reveal the gecko patterns shown in Figures 10 and 11. This resulted in unsymmetrical girder section, which required special design and detailing. During design of these girders, the design team worked with the contractor and local girder precasters to determine the most cost effective way to incorporate the form-liner into the girder prior to prestressing.

Figure 10: Exterior Girder with Embedded Gecko & Cacti Pattern

Figure 11: Construction prior to Deck Pour

Pier lines on both sides of the bridge feature half circle pedestrian alcoves supported by two precast curved corbels as shown in Figure 12. These alcoves are 9'-9" in radius and feature precast park benches. Eventually, the alcoves will also feature the work of local artists or informational plaques on the local history and environment. Inviting pedestrians to rest and view the natural surroundings, the alcoves allow the bridge to act as more than simply a conveyance over the Gila River.

Figure 12: Pedestrian Alcove with Precast Corbels

The alcove slab and adjacent sidewalk area feature exposed aggregate with stain. The exposed aggregate finish was achieved by sandblasting around the patterns after concrete placement. Further enhancing each alcove is a bat and cacti pattern, like the one in Figure 13, that is displayed on the back face of the F-barrier.

Figure 13: Relief Pattern on Back Face of Barrier

The pier columns received a treatment of stain and sand-blasted patterns, as Figure 14 shows. The stain on each column extends up to the 100-year storm elevation in order to suggest the abrasive and eroding capability of the floods over time.

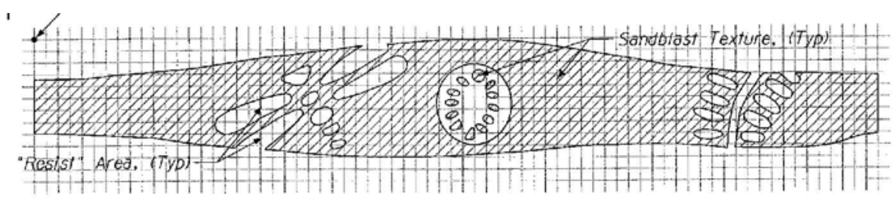

Figure 14: Stain and Pattern on Columns (Constructed Photo not available yet)

CONCLUSIONS

From charettes to construction, design of the Cotton Lane Bridge over the Gila River in Goodyear, Arizona, balanced the stakeholders' need for an attractive, functional, and pedestrian-friendly bridge with their concerns about environmental context and sensitivity. The collaborative nature of the conceptual design expedited the design process. Such concern for preservation of the local landscape influenced designers to use specific colors, materials, and textures, while the awareness of the Gila's River environment and inhabitants shaped the bridge's form. Above all, the versatility of precast concrete, from the modified exterior girders to the curved corbels at the alcoves, enabled and provided for a more cost efficient, environmentally friendly, quickly constructed and unique bridge.

REFERENCES

1. Hanks, Kurt, “Rapid Viz, Third Edition, A New Method for the Rapid Visualization of Ideas”, William Kaufmann Inc., 2006.
2. AASHTO 2004 LRFD Bridge Design Specifications, Customary U.S. Units, 3rd Edition, American Association of State Highway and Transportation Officials, Washington, D.C.