Precast/Prestressed Concrete Slabs used in Riverfront/Lakefront Walkways

David A Tomley, P.E., KZF Design, Inc., Cincinnati, OH
Donald E. Flynn, P.E., KZF Design, Inc., Orlando, FL

ABSTRACT

This paper presents an overview of various uses of precast/prestressed concrete for Riverfront, Lakefront, and/or Oceanfront walkways and projects. The authors will highlight several Waterfront projects along the Ohio River that have multi-faceted characteristics that are unique to their Communities that they serve and also touch on the master planning, preliminary engineering, permitting, and final engineering phases of the projects.

The paper discusses the design considerations, highlights the precast elements used, and presents the details used for the Riverfront projects.

The paper also summarizes the benefits of using precast/prestressed concrete for Riverfront/Lakefront projects.

Keywords: Riverfront, Lakefront, Oceanfront, Waterfront, Aesthetics, Master Planning, Engineering, Environmental, Regulatory Agencies, Boat Ramps, Precast Deck Panels, Precast Deck Planks, Precast Concrete Slabs, Ohio River, Mooring

INTRODUCTION

Waterfront revitalization projects are popping up throughout the mid-west and along the Ohio River in numbers driven by Communities in an effort to engage the public and take advantage of the Rivers natural beauty and Commerce potentials.

KZF Design has been involved with several successful Waterfront projects located on the Ohio River that incorporate unique characteristics that blend with the respective Communities needs, desires, and local conditions.

The unique background to the projects, master planning components, regulatory agency involvement and collaboration, preliminary engineering, aesthetics, hydraulics, and final engineering design issues will be presented.

A major component to any Waterfront project is the utilization and integration of footpaths and/or walkways. Precast/prestressed concrete slabs are a natural selection due to; the inherent concrete strength, durability, available to endure harsh environments, capacity loading, span length designs, multiple connection alternates, and ability to blend environmentally with its surroundings. One other highly utilized precast element consists of precast/prestressed concrete box beams that are typically used for intermediate supports and/or edge beams. Either precast reinforced concrete slabs or solid precast box beams can be utilized for boat ramps.

The authors will also highlight the unique design considerations for waterfront projects and present some of the more common details and successful solutions that have been developed using precast/prestressed concrete slabs and box beams.

WATERFRONT PROJECTS

PROJECT 1: MAYSVILLE, KENTUCKY

Fig. 1 Maysville Riverfront (Maysville, Kentucky) on the Ohio River

The initial phase of the Maysville Riverfront consisted of an Implementation plan that embodied local interests and visions. Phase one consisted of an entrance way (i.e., Limestone Landing, see Figure 2) from the City of Maysville through the flood wall down to the Riverfront along with adding an attractive terraced stair and ADA compliant ramp system to provide access under the railroad and to the Ohio River (see Figure 3).


Fig. 2 Limestone Landing and Opening through Floodwall

Fig. 3 Terraced Stair and ADA Compliant Ramp

The next phase consisted of the construction of a handicap fishing pier along with an area for temporary pleasure boat access through use of a floating dock. The fishing pier utilized precast/prestressed concrete box beams for the edge supports supporting precast/prestressed concrete slabs (see Figure 4).


Fig. 4 Handicap Fishing Pier under Construction

The following photograph delineates the opening in the floodwall and the Waterfront entrance under the Railroad (see Figure 5).

Fig. 5 Finished Handicap Fishing Pier

The current phase of construction for the Maysville Waterfront entails the extension of the sidewalk to an overlook/seating area leading down to an elevated ramp and footpath with scenic overlook bump-outs. The elevated ramp and footpath currently under construction (see Figures 6 and 7) utilizes 4'-6" wide by 20'-0" long by 8" thick precast/prestressed concrete slabs. Carr Concrete a Subsidiary of R.W. Sidley, Inc. was the precast concrete manufacturer of the precast/prestressed concrete slabs.

Fig. 6 Maysville Waterfront Expansion (currently under construction, July 2008)

Fig. 7 Maysville Waterfront Expansion showing steel support cross-beams

The elevated footpath consists of two 4'-6" wide by 20'-0" long by 8 inch thick precast/prestressed concrete slabs for an out-to-out walkway width of 9'-0". Scenic

overlook areas were created by using two additional precast slabs to provide a total out-to-out viewing area of 18’-0”.

The following photograph (see Figure 8) shows the precast/prestressed concrete panels in the precast yard.

Fig. 8 Maysville Waterfront (Precast/Prestressed Concrete Slabs)
Photo provided by Carr Concrete (A subsidiary of R.W. Sidley, Inc.)

Surprisingly, the Maysville Riverfront planning and implementation efforts began nearly 20 years ago. Each phase had unique project challenges and funding stream mechanisms that continued the expansion of the Riverfront. Future phases consist of extending the walkway downriver back under the railroad traversing parallel to the flood wall and finally back through the flood wall connecting with the City of Maysville on the Southern end of town. Once completed, the Maysville Riverfront will have dual entrances that will better connect and serve the community in years to come and will facilitate the enjoyment and utilization of the Ohio River for future generations.

PROJECT 2: RISING SUN, INDIANA

The City of Rising Sun, Indiana retained KZF Design to develop a master plan (see Figure 9) along with the subsequent engineering implementation phases. Our experience has shown that each Riverfront project has different characteristics and/or driving features differentiating them from other Riverfront projects. The City of Rising Sun’s Riverfront Project included Restoration and Soil Stabilization as the primary design elements. Other project elements included retaining wall terraces with seating (see Figures 10 and 11), gateway/entrance plaza (see Figure 12), and boat mooring design.

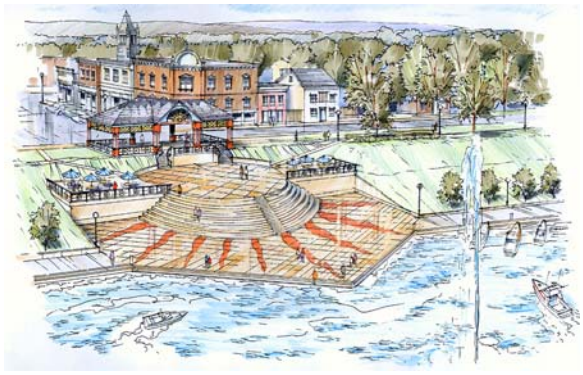

Fig. 9 Rising Sun, Indiana Riverfront Master Plan Rendering

Fig. 10 Retaining Wall Terraces

Fig. 11 Overlook Seating

Fig. 12 Rising Sun Riverfront Gateway/Entrance Plaza

With the Grand Victoria Casino located nearby, the new Rising Sun Riverfront is a paramount feature of the community along the Ohio River.

PROJECT 3: ASHLAND, KENTUCKY

The Ashland Riverfront's First Phase of construction will be advertised for construction in July, 2008. The initial planning and master plan was first developed in order to create a roadmap for the later implementation and subsequent engineering design and construction phases. Several models and 3-D perspectives were created to depict the proposed work (see Figure 13).


Fig. 13 Ashland Riverfront Phase One Perspective

A unique characteristic with the Ashland Riverfront project is the reclamation of approximately one acre of lost Riverfront measured from the normal pool elevation due to erosion over the last century.

The following Figure 14 depicts the limits of the proposed work in relation to the existing edge of the Ohio River. The proposed work extends out and varies into the Ohio River approximately 50-100 ft.

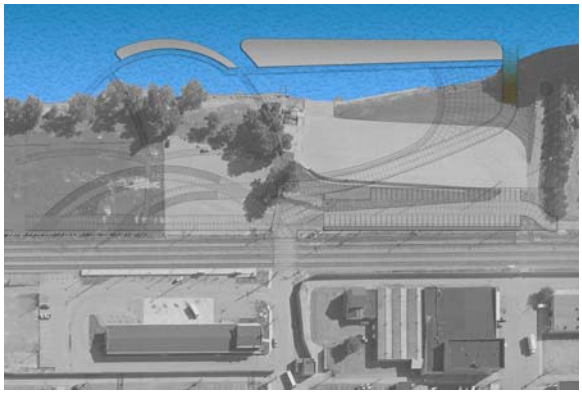
Fig. 14 Ashland Riverfront Phase 1 Proposed Limits of Work

Another important element to the project consisted of the ability for either large commercial riverboats or small pleasure boats to dock along the Riverfront. As such, the proposed work included a 500 ft. straight bulkhead in order to accommodate the larger commercial riverboats and a 250 ft. curved bulkhead to accommodate the smaller pleasure boats. Adjacent precast concrete slabs (4'-0" wide x 26'-0" long x 1'-2" thick) were utilized to construct the boat ramp.

One major project challenge was to determine the extent of Phase One Riverfront work within the allocated project budget.

The following Figure 15 delineates the Phase 1 work in relation to the overall master plan.

The Phase 1 work is approximately 40% of the overall master plan (17.8 acres) and is approximately 7.1 acres of construction for Phase 1.

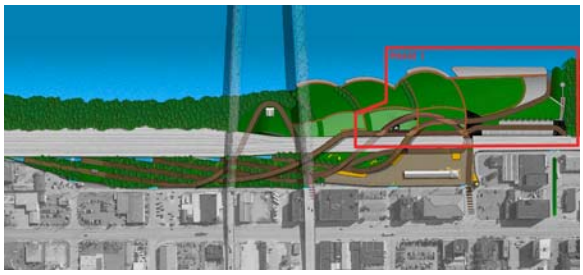
Fig. 15 Ashland Riverfront Phase 1 of Overall Master Plan

The Ashland Riverfront project incorporates aesthetic features such as colored concrete, formliners on the retaining walls, brick walkways, entrance plazas utilizing black granite, a scenic overlook, along with other site amenities. Future phases will include pedestrian bridges over the railroad, water features, and amphitheaters.

All of the three waterfront projects mentioned above included collaboration with and permit application and review by the Army Corps of Engineers and the associated State Division of Water Agencies. Many waterfront projects contain existing railroads that have related review and project coordination aspects to address. Another important

feature/aspect too many of these waterfront project is access to and from the water. As such, safe boat mooring has to be integrated into the project and adequate provisions to accommodate boat access needs to be built into the overall design. As with any major river throughout the US, water surface elevations can change drastically during major storm events. The water surface elevation fluctuations can, and sometimes do, dictate design decisions and construction means and methods.

As outlined in this paper, waterfront projects are a vital part of communities throughout the Midwest along the Ohio River. The continued use of precast/prestressed concrete slabs and/or box beams can benefit these types of projects by providing design solutions that match project objectives, goals, life-cycles, and budgets.

DESIGN CONSIDERATIONS

In standard building design, engineering and design of precast/prestressed slab units are usually basic and straight forward where only floor dead load and floor live loads are the main design consideration and floor diaphragm stresses/transfer load details are factored into the engineering analysis. Connections are analyzed and typical panel closure strips and reinforcement details are incorporated into the engineering plans and details.

In riverfront, lakefront, and oceanfront walkways, additional design considerations will need to be incorporated into the design of the precast/prestressed slab units.

The below review areas can almost be used as a check list for the design of the walkways and foundation systems for Riverfront, Lakefront, and Ocean Walkways.

There are a number of dead load issues that need to be considered in the design of the precast/prestressed concrete slab/panel in addition to the self weight of the panel to include:

Hand railings,
6”x6” possible concrete curbs,
Decorative tile overlays and face brick inlays, if used,
Electrical conduit lines for lighting,
Possible potable/drinking water lines,
Possible sewer/small utility lines, and
Depending on environmental issues, small drain inlets, and drain piping may be required.

Several Live loading requirements that need to be considered include:

Normal pedestrian walkway loading
Extreme Event / Crowd Loading
Code review officers and Emergency Personnel may require Access by Emergency Vehicles.

City/County Maintenance departments may require Access by Maintenance Vehicles.

If vehicles are required to access the walkways, the designer will need to investigate which vehicles are to be used on the walkways because of the different live loading requirements. The information on the vehicles used can normally be obtained from the Department Managers. Final decisions should be sought with the City Project Manager due to the fact that Vehicle Loading can control the design. Impact factors for vehicle live loading may be able to be reduced from those required in the LRFD Bridge Design Manual because vehicles will only travel at low speeds.

Extreme Event/Crowd Loading should also be reviewed with the City Project Manager which will correspond with Lakefront/Ocean Front events of the city/town. If these events draw large crowds, then walkway areas may need to be constructed to 8 feet and 12 feet widths, or possibly larger, in order to meet building code requirements for travel paths and travel distances.

Other standard loads which will be incorporated into the walkway design are:

Wind Loads (depending on the Location),
Snow Loads (depending on the Location), and
Seismic Loading (depending on the Location).

UPLIFT DESIGN CONSIDERATIONS

In consideration of the uplift design issues for the precast/prestressed slab units, wind loading pressures are usually not a design control element due to the weight of the concrete slab. Although, in oceanfront walkways wind speeds will become an issue in uplift design and reverse stresses in the precast/prestressed slab units have to be reviewed.

Waterways and rivers can have several major fluctuations in water elevations throughout the year, as we have witnessed in the US. Slab elevations need to be reviewed in reference to 100 year and 500 year flood elevations. If the slab unit elevations are set below these elevations, then hydrostatic pressures can develop underneath the slabs at maximum current flows. Most of the time, the USGS and/or local water management districts will have maximum stage elevations, flood design elevation, and maximum flow velocities.

Load consideration for Foundation/Piles will be as follows:

Debris Impact, Ice Flows, Wave Impact, Current Flows, River Flow Water Pressure (depending on Location), and Scour Depth analysis on Precast/Prestressed Piling or HP Steel Piles.

Foundation loads on the pile systems may present more of an in-depth analysis depending on the location. The LRFD Bridge Design Manual and the Coastal Construction Manual gives a more in-depth review of these load applications.

SURCHARGE ROADWAY LOADING AND RAILROAD SURCHARGE PROXIMITY LOADING

Depending on the site location and vicinity of the roadway and/or a railroad, live load surcharges can have effects on the foundation piling. Standard classical analysis methods can be used to incorporate these design loads on the foundation system. The "Boussinesq" method of load/soil stress distribution is a classical analysis method that can be used to apply Lateral Loads to the foundation for design analysis.

Serviceability Issues will involve:

Control of Deflection Limits
Span Lengths, depth/length ratios, and
Slip Resistance walking Surface Finishes.

The PCI Design Handbook has a Span Data Table that provides preliminary estimates for prestressed panel spans, loading, and preliminary reinforcement. These initial design sizes will need to be reviewed in reference to the above load conditions. For slip resistance walking surfaces, normal brush/broom finish will work in most applications. Concrete sealers may be applied by the precaster for curing operations. Additional issues regarding deflections will need to be reviewed in reference to finished topping, i.e. Ceramic Tile overlays, face brick inlays, etc.

MOORING TIE-OFF LOADS

Additional Load Designs that may need consideration are large boat and mooring tie-off loads. If large boats tie off to the walkway platforms, then these loads will need to be transferred into the foundations system. Boat area, wind speed, draft depth of the boat hull, and the location of tie-off points will need to be known in order to calculate these loads. Maximum wind pressure to be applied to the projected area of the boat, and maximum water flow velocity/pressure applied to the hull draft area to produce maximum forces. The total force will be distributed over the minimum number of tie off points to product the mooring design load. Usually, these tie-down loads are transferred to bollards, cleats, or posts connected to the concrete slabs thru embedded weld plates.

LONG-TERM PERFORMANCE AND ENVIRONMENTAL CONDITIONS

Durability of concrete is well known throughout the industry and is the best-suited material for construction of river, lakefront, and ocean walkways. With adequate concrete cover, reinforcement details, appropriate use of epoxy coated reinforcement, concrete construction will produce the longest life structure and give the best performance.

ENGINEERING AND DESIGN OF PRECAST/PRESTRESSED WALKWAY PANELS, CAPS, AND PILING

Engineers, Designer's, and Precaster's can use any one of the available computer commercial programs for the Design of the Precast/Prestressed Elements. The PCI Design Handbook is available for Preliminary Design. If complex geometry or issues arise, the designer has computer programs readily available in the Finite Element Analysis area. Each complex geometry area can easily be modeled into the computer program and designed for the applied loading conditions.

CONCLUSION

Precast/prestressed concrete slabs and box beams have been used successfully on various waterfront projects throughout the US and offer communities design solutions that integrate with their project goals and objectives.