WIDENING OF WESTERN DISTRIBUTOR VIADUCT IN SYDNEY NSW

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SYNOPSIS:

The existing viaduct is a complex structure and was designed in 1967. It is 507 metres long and consists of 19 spans of varying length from 23 to 30 meters. The width of the deck also varies. The superstructure is a reinforced concrete multicellular deck with a prestressed concrete diaphragm at each pier. This superstructure is continuous over two or three piers and has seven drop-in spans supported by half joints. The substructure consists of two reinforced concrete columns connected by either hemispherical bearings or built into the superstructure.

The paper describes the design of the viaduct widening and a developed unique scheme to support this widening. This scheme eliminated the need to strengthen the existing structure and overcame many site constraints. The widening is 271 meters long with variable width from 2.3 to 5.5 meters and consists of steel structure supported on reinforced concrete corbels. Each pair of corbels was clamped to the existing column using stress bars. The widening was constructed under traffic conditions.

EXISTING VIADUCT

The existing Western Distributor viaduct was designed in 1967.

The Bridge Design Code current at the time of the viaduct design was National Association of Australian State Road Authorities Highway Bridge Design Specification. This code has been since superseded in 1976 and the design code at the time of widening design was 1996 AUSTROADS Bridge Design Code.

The existing viaduct is 507 meters long and consists of 19 spans of varying length from 23 to 30 meters.

The roadway splits into two separate viaducts at the northern end for the last 120 meters. The separate viaducts are approximately 13 meters wide. The main section of the viaduct varies in width from 16 to 23.5 meters. The designed widening provided a more uniform width of deck.

There is a short section of incomplete roadway at a lower level on the viaduct. This section was built as a part of future extension of the Western Distributor that was not built. The viaduct was designed with a provision for a two level viaduct extension on the western side of the existing roadway.

The superstructure is a reinforced concrete multicellular deck with a prestressed concrete diaphragm at each pier. This superstructure is continuous over two or three piers and has seven drop-in spans supported by half joints. There is an expansion
and a fixed joint at each end of the drop-in spans. However, there is a propped cantilever deck at the northern end of the viaduct.

The substructure consists of two reinforced concrete columns connected by either hemispherical bearings or built into the superstructure. Typically the columns are 1.2 x 1.5 metres and supported on pad footings founded on sandstone. A few piers are founded on piles socketed into sandstone.

Figure 1 shows a photo of the existing viaduct prior to widening.

![Figure 1: Part of Existing Western Distributor Viaduct Prior to Widening.](image)

**STRUCTURAL CAPACITY CHECK OF THE EXISTING SUBSTRUCTURE**

The substructures were analysed using a 3D MICROSTRAN model. The structural capacity of the columns was checked using the RTA in-house General Column Analysis and COLDES computer programs. All the analyses were carried out in accordance with the 1996 AUSTROADS Bridge Design Code incorporating the limit state design philosophy.

The outcome of the structural capacity check revealed the following:

- The columns have reserve axial capacity to carry the widening.
- Existing hemispherical bearings have no reserve horizontal capacity to carry additional loads from the widening. Replacement of these bearings would involve complex work and closure of the viaduct to traffic.
- The columns have limited reserve horizontal capacity because of the increased horizontal forces in the 1996 AUSTROADS Bridge Design Code compared with the previous codes.

**WIDENING STRUCTURE AND SUPPORT SCHEME**

The designed widening structure is 271 meters long with variable width from 2.3 to 5.5 meters.

Several factors affected the selection of the support scheme for the widening such as space restriction for any additional columns, the availability of any reserve
capacity in the existing structure to carry the additional loads from the widening, articulation of the existing viaduct, vertical clearance, aesthetics, economy and constructability above busy roads, footpaths, buildings and private developments.

The superstructure of the widening consists of fabricated steel girders composite with a cast-in-place deck slab. It is supported by transverse steel girders, which in turn are supported by reinforced concrete corbels. Each pair of corbels was clamped to the exiting column using stress bars. The general arrangement of the widening, cross section and locality plan are shown in Figure 2.

The developed unique support scheme will ensure the following:

- Centrally located reactions from the widening on the existing columns. This reaction is within the reserve axial capacity of the existing column.
- Minimum additional dead load from the widening.
- The additional loads are carried directly by the existing substructure. This arrangement was chosen to keep the imposed horizontal loads on the existing substructure within its reserve capacity and to avoid strengthening.
- The articulation of the new support system will not impose excessive loading on the existing structure and will not change the articulation of the existing viaduct.

The features of the widening design and support scheme are further described below.

**LONGITUDINAL STEEL GIRDERS**

Each span of the widening consists of fabricated steel girders composite with a reinforced concrete deck slab.

The depth of the girders is reduced at each end to form half joint. The bearings under each longitudinal girder are located at the centreline of the existing columns. This arrangement was selected in order to impose a central loading from the widening to the existing columns.

The longitudinal girders are simply supported for the following reasons:

- To minimise horizontal loads from the widening to existing columns.
- For better distribution of the horizontal and longitudinal forces from the new deck to the existing columns.
- To reduce the movement in the new deck joint and differential longitudinal movement between the existing and new superstructure.

The longitudinal girders were designed to minimise the differential deflection between the new and existing superstructures.
FIGURE 2:
ELEVATION OF WESTERN DISTRIBUTOR VIADUCT, CROSS SECTION OF EXITING AND WIDENING STRUCTURE AND LOCALITY PLAN
DECK SLAB

The widened deck slab consists of in-situ concrete topping on precast permanent formwork spanning between the longitudinal girders. A longitudinal deck joint is provided between the new and existing superstructure. This joint, as shown in Figure 3, permits future adjustment of design surface levels of the widened deck to accommodate deflection of the steel girder due to shrinkage of deck slab.

![Figure 3: Longitudinal Deck Joint](image)

LONGITUDINAL SUPPORT GIRDERS

The longitudinal support steel girders are supported by the transverse girders. These longitudinal girders support the main longitudinal girders and distribute the load evenly between the two transverse girders. These girders also brace the cantilever part of the transverse girder.

MAIN TRANSVERSE SUPPORT GIRDERS

The main transverse steel girders are supported by reinforced concrete corbels, which are clamped to the existing column with prestressed bars. These girders are cantilevered out to support the longitudinal support girders. This arrangement subjects some girders to uplift under maximum live load on the widened deck and a pot bearing was designed for this uplift load.

The lateral and torsional restraints at the support of the transverse girders are provided by concrete cross ties and cast-in place slab within a reinforced concrete circular collar. This concrete collar was enlarged to form an architectural feature as recommended by the Urban Designers.

The following arrangement was specified in order to allow for thermal expansion of the transverse girder:
The two supports under each transverse girder were one guided sliding pot bearing and the other fixed pot bearing.

A gap was specified between the concrete collar and the longitudinal faces (parallel to traffic) of the existing column.

Paint or 1mm bond breaking were applied to the existing column along the transverse faces in contact with the concrete collar. Elastomeric bearings were cast in these contact areas to eliminate side impact to the existing column from the collar.

**REINFORCED CONCRETE CORBELS**

The main transverse girders are supported at the column centre lines by reinforced concrete corbels cast onto the sides of the existing columns. The loads caused by the widening are transferred centrally to the existing columns and are within their capacity.

It was specified to core drill into the existing columns to provide access for stress bars, cast the corbels and then prestress the corbel to the existing columns.

Additional two hollow box corbels were designed on the other faces of the columns for architectural reasons and were used to contain the anchorages of the extra bursting steel for the existing columns. This bursting steel was required because of the change in cross section sizes between the corbels and their support columns.

The prestressing requirements and details of each corbel were selected to suit the existing column reinforcement and loadings. Figure 4 shows plan and side view of the corbel clamped to existing column.

**ARCHITECTURAL REQUIREMENTS**

After completion of the detailed design by the RTA Bridge Engineering, a number of distinctive architectural features were incorporated in the design by Wood/March Pty Ltd Architecture. These features enhanced the appearance of the bridge and included perforated metal cladding, stainless steel architectural corbel covers, large circular collars and end cover plates. Some of these features are shown in Figure 5.

**CONCLUSION**

The designed unique support scheme overcame space constraints for construction of new columns and ensured application of the smallest possible reaction centrally on the existing columns. The articulation of the support system did not impose excessive loading on the existing structure and did not change the articulation of the existing viaduct. In addition, the existing substructure is capable to carry the proposed widening loading without the need for strengthening.
The widening design of Western Distributor Viaduct incorporated unusual features for bridge construction, significant architectural features and practical construction detailing which resulted in easy and safe construction under traffic conditions.

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DISCLAIMER

The opinions expressed in this paper are those of the author and do not necessarily reflect the policies of the Roads and Traffic Authority of NSW.
FIGURE 4: PLAN AND VIEW OF CORBELS CLAMPED TO EXISTING COLUMN
FIGURE 5: PHOTO OF THE WIDENING AND SOME ARCHITECTURAL FEATURES.