Notes of Design and Analysis

Townhead Interchange

Ramp K-West

1) Description of Structure

The bridge carries three 12ft. lanes and a 10'0" hard load shoulder over Ramps A & B.

The total length is 262 ft. in three spans of 106'-86-60'. The width between kerbs is 48' and 55'-8' overall. The skew is 54°. (See general Arrangement Drg. No.63040/600). The bridge is continuous over the three spans which comprise two prestressed concrete box beams connected by a reinforced concrete deck slab. The width between centres of boxes is constant at 26'0", but the cantilevered deck slab at the outer edges is of variable width due to the double curvature of Ramp K. The concrete used in beams and deck slab is 6000/3/4. Columns are rectangular in plan and taper towards the base. Concrete class 4,200/3/4. The bridge is fixed on hinge bearings at the west end and each beam is supported on two sliding bearings on each of the interior columns and at the east end. Foundations on firm sandstone 4 ft. below F.R.E.L.

2) Alternatives considered.

Three box solution.

3) Preliminary Design

Longitudinal Bending Moments etc., to establish beam sizes. Only a rough check on stability of boxes was made at this stage. It was assessed that H.B. Moments would be within the H.A. figures for the critical sections. The two box solution was chosen because it was thought that since each box would support two lanes of H.A. loading, the H.B. loading would approximate to this on the largest span.

A) Final Design

The system adopted was very similar to that used in Ramps J & K east. The following modifications should be noted.

a) Since each beam was to be stressed in one operation from each end the calculations were simplified the construction sequence did not have to be considered.

b) Due to the ill-conditioning of the spans, additional prestress was required over the supports between the 106 ft. and 86 ft. spans.

C) The end diaphragms caused appreciable hogging moments at the ends of the box beams and also added considerably to the overturning moments at the end supports. However as a diaphragm of some sort was required to stiffen the end of the deck slab, it was decided to retain them.

Abutments

d) The west abutment is a cellular structure with walls acting mutually as counterforts. The total length of the abutment is 115 ft. with no expansion joints. Calculations for stability were made and the individual slabs were designed using the method shown by Reynolds in the "Reinforced concrete Designers handbook". See Dg. No.63000/614.

The east abutment was designed as two separate foundations one for each box beam, connected only by a perimeter wall against which the expansion joint is placed. See Dg. No.63040/603. The only complication here is analysing the perimeter wall which was attached to the abutments at a skew angle. Finally the wall was designed for bending in two directions as though simply supported, but a fixing moment was assumed when calculating the steel connecting the perimeter wall to the abutments.

Columns

e) As for Ramps J & K east were designed using Pannell's method. Footings however were separate for each column in view of the distance apart. Column fottings were rectangular and each size was dependant on keeping local bearing pressures due to Bi-axial bending within the permissible limit of 4 tons/sq.ft.

g) <u>General Comments</u>

Comments are generally as those for Ramps J & K East. However, the stability problem though very severe at the ends of the deck, due largely to the diaphragms was less critical on the intermediate supports. This was due to the boxes being wider and the deck slab more flexible than in Ramps J & K East.

The overturning problem at the ends would have been reduced by removing the diaphragms, but probably not enough to eliminate it altogether.

A possible improvement to the shceme would be to have boxes wider at the bottom for stability and keep the deck slab as slender as possible. Thereby reducing both the distribution and the overturning moments. Alternatively put the beams closer together with a light articulated deck slab over.

h) <u>References</u>

<u>Columns</u>. "Design of Bi-axially-loaded columns by the ultimate-load method. by F.M. Pannell. Concrete and Constructional Engineering Oct. 1960.

<u>Torisional Reinforcement</u>. "An elastic theory for the torisional strength of rectangular reinforced concrete beams". by J.H. Cowan. Magazine of Concrete Research No.4 July 1950.

<u>Influence Lines</u> I.C.T. programme. List C.5 398.

<u>Grillage Analysis</u> I.C.T. Programme. List C.5 357.

<u>End Block & Column Heads</u> C & C.A. Research Reports 9 & 13.

<u>Ultimate shear</u> A.C.I. 318/63 chapter 26 Section 2610 (a)
Flow diagram Drg. 63040/559
Programme M. Owen.

<u>Fixed End Moments in Haunched Slab</u> "Handbook of Frame Constants".