Analysis and Design of a Composite Non-Cellular Steel/Concrete Deck for the Jerseyside Wharf Extension

Shawn P. Kenny

ANALYSIS AND DESIGN OF A COMPOSITE NON-CELLULAR STEEL/CONCRETE DECK FOR THE JERSEYSIDE WHARF EXTENSION

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HARBOURS AND INFRASTRUCTURE BRANCH
ST. JOHN'S, NEWFOUNDLAND

Work Term VI Report
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December 16, 1987.

Department of Fisheries and Oceans
Harbours and Infrastructure Branch
St. John's, Newfoundland

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Prepared for :

The Division of Co-ordination
Faculty of Engineering and Applied Science
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St. John's, Newfoundland

Submitted by :
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December 16, 1987.

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GENERAL NOMENCLATURE

Codes and Standards :

CISC - Handbook of Steel Construction, Canadian Institute of Steel Construction

CSA CAN3-S6-M78 - Canadian Standards Association, "Design of Highway Bridges"

NBCC and Supp. - National Building Code of Canada (1985) and Supplement to the NBCC

List of Symbols :

A_b - Area per steel reinforcing bar. (mm^2)
A_s - Area of steel reinforcement. (mm^2)
A_v - Area of shear reinforcement. (mm^2)
b - Breadth of design section. (mm)
C_a - Accumulation factor, NBCC (1985)
C_b - Basic roof snow load factor of 0.8, NBCC (1985)
C_s - Slope factor, NBCC (1985)
C_w - Wind exposure factor, NBCC (1985)
d - total depth of concrete section required for design. (mm)
d_b - Steel reinforcing bar diameter. (mm)
d' - effective depth of section, measured from the extreme compression fiber to tension reinforcement. (mm)
DF - Moment distribution factor
DPW - Federal Department of Public Works
f'_c - Compressive strength of concrete at 28 days. (MPa)
f_y - Yield strength of steel reinforcements. (MPa)
I - Impact load fraction, max. value of 0.30, CSA CAN3-S6-M78
K - Beam element stiffness. (EI/L)
K_p - Ponding effect factor for deflection.
K_r - Resistance factor for bending. (MPa)
l_d - Development length of steel reinforcements. (mm)
l_n - effective length of clear span. (mm) or (m)
l' - effective length of clear span. (mm) or (m)
L - span length, in metres, which is loaded to produce maximum stress in the member. (m)
M - Bending moment per metre width of slab. (N m/m)
M_f - Fixed end moment. (kN m)
M^r - Resisting moment of metal formed deck. (kN m)
P - Axle load on one rear wheel, P = 0.4W , or concentrated point load. (kN)
S - Specified snow load due to accumulation, (kPa), or Sectional modulus of metal formed deck in (mm3/m).
S_o - Ground snow load, NBCC Supplement. (kPa)
v_u - Design or ultimate shear stress. (MPa)
v_c - Allowable shear stress of concrete. (MPa)
V_r - Shear force resisted by metal formed deck. (kN)

GENERAL NOMENCLATURE

cont.'

V_u - Design or ultimate shear force for concrete. (kN)

w_d - Total uniform dead load. (kPa)

w_{d1} - Uniform dead load due to infrastructure. (kPa)

w_{d2} - Uniform dead load due to self-weight of the concrete slab. (kPa)

w_l - Uniform live load due to the specified snow load. (kPa)

w_f - Appropriate factored dead or live load. (kN/m) or (kPa)

W - Combined wheel load on the first two axles or the MS loading in kilonewtons. (kN)

γ_c - Unit weight of concrete. (kg/m^3)

- Specified unit stress of the metal formed deck. (MPa)

Δ_o - Initial deflection of the metal formed decking due to weight of concrete slab and self weight of deck. (mm)

Δ_t - Total deflection of the metal formed decking, which includes the ponding effect. (mm)

LIST OF FIGURES

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The analysis and design of a non-cellular steel/concrete deck for the Jerseyside wharf extension is presented within this report. The various structural analysis techniques and design methods utilized are logically and explicitly illustrated.

The engineering design is based on the CSA Standard CAN3-S6-M78 "Design of Highway Bridges" and governing clauses of the National Building Code of Canada (1985).

The loads consist of an MS 200-77 design vehicle, live snow load, and a uniform dead load of 20 kPa. Assuming simple supports, where the pile cap and deck are interconnected, the shear force and bending moments were determined using the technique of moment distribution. The maximum values for shear and bending moment obtained by analysis were 247.4 kN and 45.3 kN m/m respectively. Specific design calculations are presented in the text and detail specifications are illustrated in Appendix D, at the end of this report.

In closing, it must be emphasized that only the concrete deck slab is being analyzed for design. The author has assumed that the piles, caps, beams, and other structural members are adequately designed and can support the loads transmitted from the deck.

1.0 INTRODUCTION

The design of a composite non-cellular steel/concrete deck for the wharf extension in Jerseyside is presented within this report. This study was initiated on behalf of the Harbours and Infrastructure Branch of the Federal Department of Fisheries and Oceans.

Jerseyside is a small community in Placentia Bay, approximately 124 kilometres from St. John's. The community is accessed via Route No. 100, which continues northeast from Jerseyside for 44 kilometres to intersect with the Trans Canada Highway and northwest for 7 kilometres to Argentia. The reader is referenced to Figures 1 through 4.

The harbour infrastructure and onshore facilities in Jerseyside provide support and service to the local communities which include; Argentia, Dunville, Freshwater, Placentia, and Southeast Placentia. The vessels berthing at Jerseyside are composed of registered vessels, and transient vessels from local communities and some areas of St. Mary's Bay.

Increased fishing activity in Jerseyside has required that additional working area be provided, particularly in the vicinity of the local fishplant. An extension to the existing marginal wharf has been proposed to alleviate the problem.

Due to fiscal restraints, only two design alternatives were considered to be economically feasible for the wharf extension in Jerseyside. These include; (i) an untreated timber cribwork structure, and (ii) a treated pile structure. The pile wharf structure was selected for the final design because of the greater life expectancy; 35-40 years as compared to 8-10 years for a untreated cribwork structure. Also, concrete decking was chosen over timber plank decking due to its longevity, strength and durability characteristics in harsh environments.

The analysis and design presented within this report was primarily intended for the wharf extension in Jerseyside; with the idea in mind that this report could be used in the future for typical design details given similar loading/structure conditions. However, extreme care should taken if one is to adopt the final design presented in this report for any other project than the one being undertaken in Jerseyside. It is highly recommended that an engineering assessment be initiated before approval for use in design of other projects.

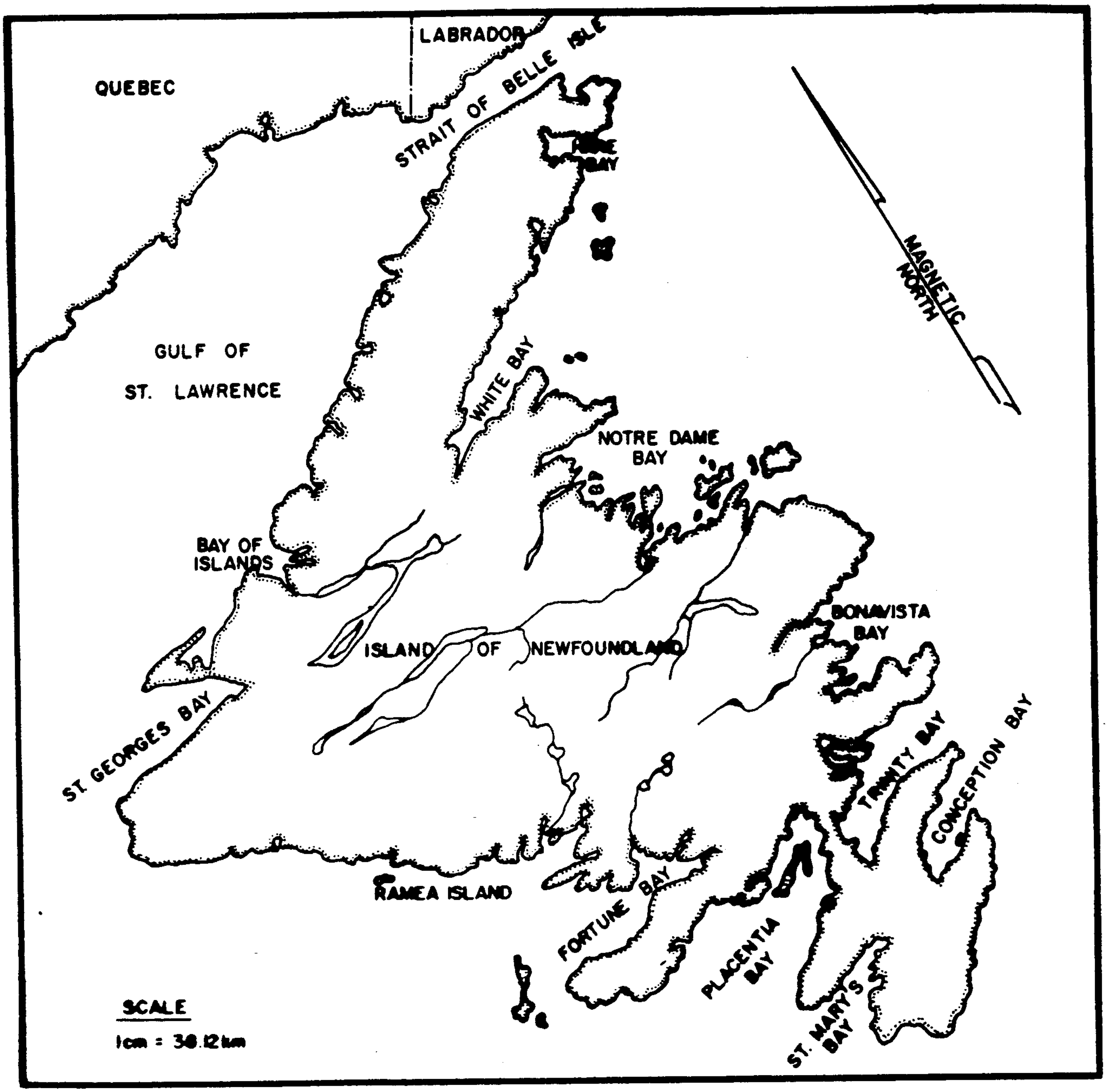


FIGURE 1 Map Of Newfoundland

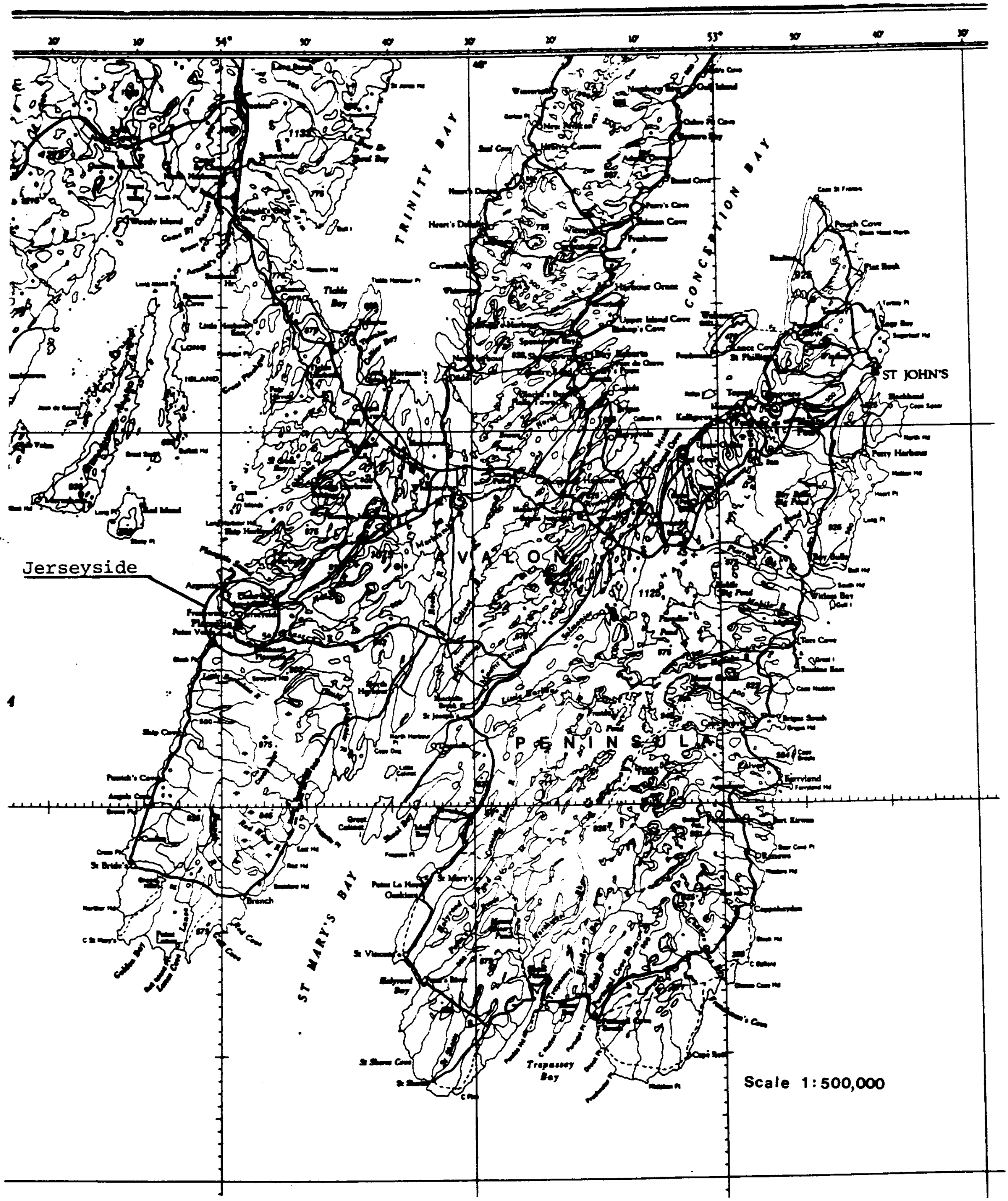


FIGURE 2 Avalon-Burin Topographic Map

Source: Energy, Mines, and Resources Canada

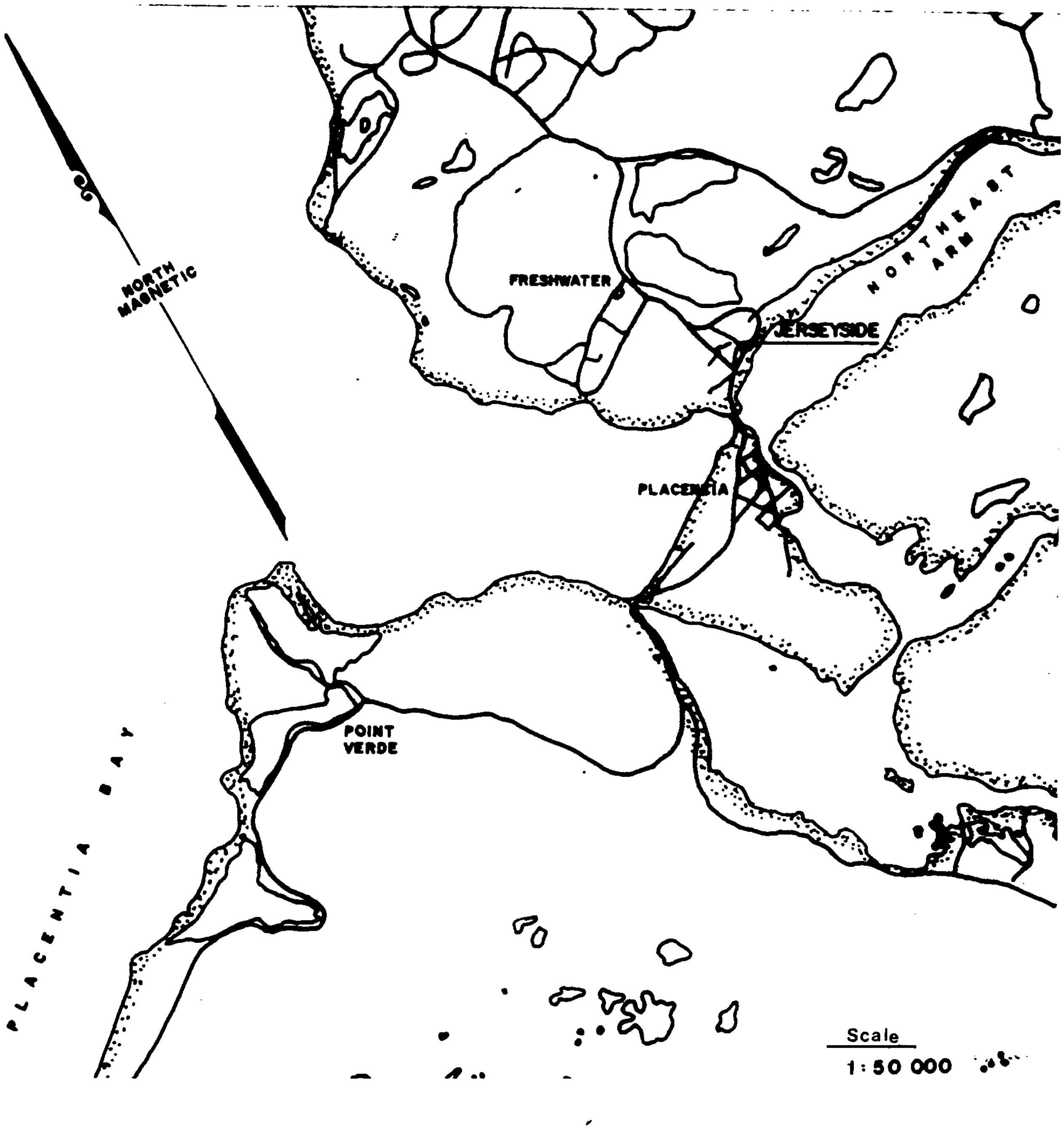
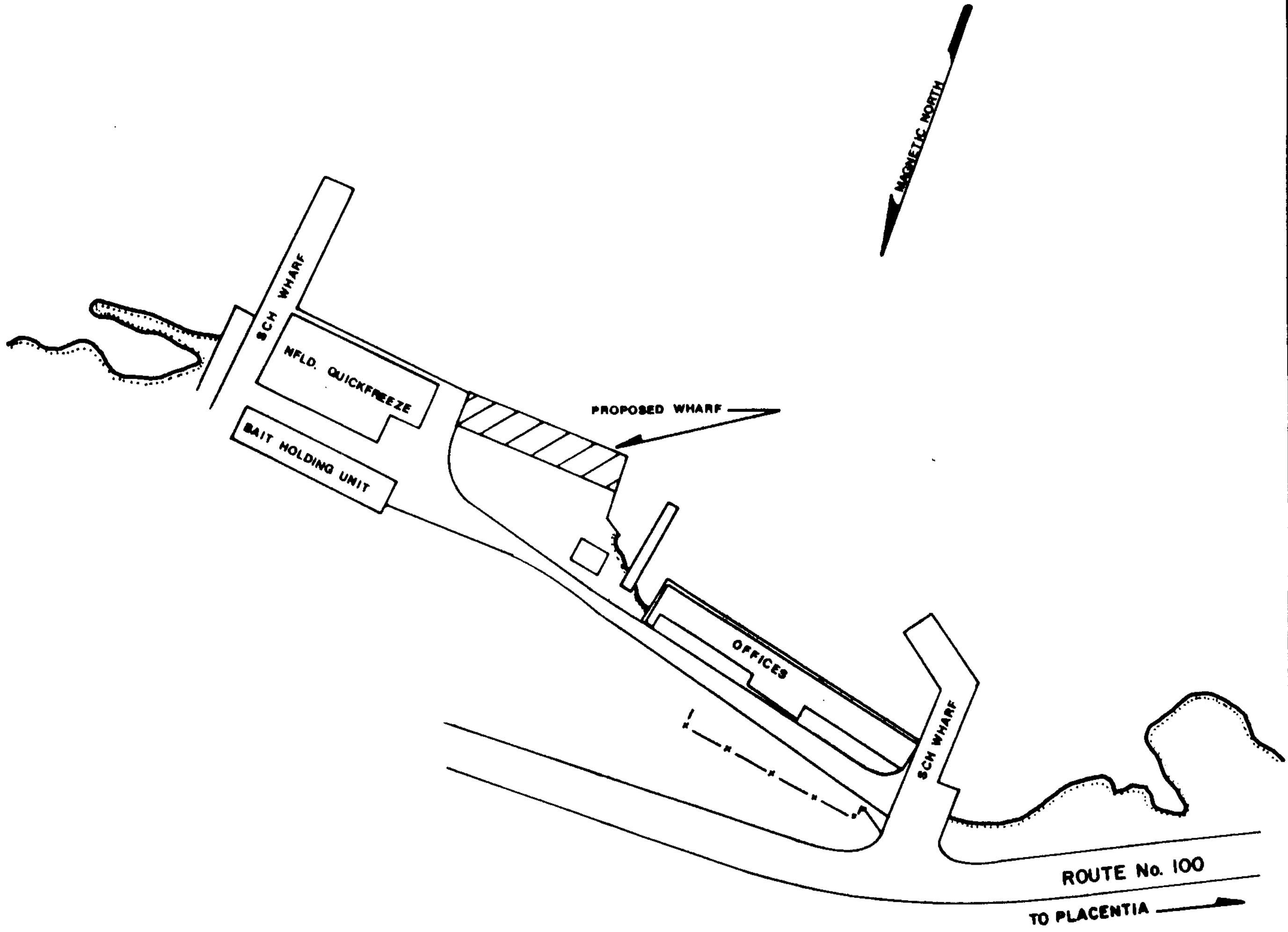


FIGURE 3 Area Map of Jerseyside-Placentia



Government of Canada / Gouvernement du Canada
Fisheries and Oceans / Pêches et Océans

LEGEND:

- PROPOSED CONSTRUCTION
- APPROXIMATE L.N.T.

A detail no. / détail no.
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

revisions / date

drawing title / titre du dessin

SITE PLAN
JERSEYSIDE

designed by / conçu par	S. KENNY
date	
drawn by / dessiné par	S. KENNY
date	
reviewed by / examiné par	NOV. 27, 1987.
date	
approved by / approuvé par	
date	
Tender / Soumission	
Project Manager / Administrateur de projets	
project number / no. du projet	
drawing no. / dessin no.	FIGURE 4

2.0 GENERAL DESIGN METHODOLOGY

2.0 GENERAL ANALYSIS AND DESIGN METHODOLOGY

The engineering analysis and design of the composite steel/ concrete deck slab is based on the CSA Standard CAN3-S6-M78 "Design of Highway Bridges" and governing clauses of the National Building Code of Canada (1985).

It is important to realize that only the concrete wharf deck slab is being analyzed. The author has assumed that the piles, caps, beams, and wharf structure as a whole are adequately designed and can support the loads transmitted from the deck. The deck is not designed as a composite section but as a normal reinforced concrete slab. The primary function of the fluted metal decking is to provide formwork for pouring the slab, and thus is designed as a form only. This allows ease of construction and some protection for the concrete from the corrosive environment.

The analysis and design is logically presented in the following sections on calculation sheets and sections and subsections are clearly defined within chapters. This allows the reader to follow step by step the procedure utilized; from where the member loads and distribution of loads are analyzed through to the design of the reinforced concrete slab.

Use of additional information such as; design tables, data sheets, and figures to further illustrate the design procedure are presented in the appropriate sections and are referenced in the notes or the rightmost column heading entitled "reference". Notes which accompany the calculation sheets further clarify the analysis and design methodology utilized.

The reader is referred to the section "General Nomenclature" for explanation of abbreviations, symbols, and equation variables.

SUBJECT: MEMBER LOADING ANALYSIS | PAGE NO. 8 | DATE DEC 4/87

DESIGNED BY: SHAWN KENNY | CHECKED BY: (RT) | REFERENCE

COMPUTATION OF LIVE & DEAD LOADS

Uniform Live Load

SNOW LOAD (kPa)

NBCC AND SUPP. (1985)

NOTES:

(i) THE GROUND SNOW LOAD, S_o, HAS A PROBABILITY OF EXCEEDENCE OF 1 IN 30 OF BEING EXCEEDED IN ANY ONE YEAR

(ii) THE CLOSEST OBSERVATION STATION FOR S_o AT JERSEYSIDE IS ARGENTIA.

(iii) DUE TO THE EXPOSED NATURE OF THE WHARF. THE WIND EXPOSURE FACTOR, C_w, MAY BE REDUCED TO 0.75

$S = S_o C_b C_w C_s C_a$

$S = (2.0\ kPa)(0.8)(0.75)(1.0)(1.0)$

$S = 1.2\ kPa$

CALCULATE THE FACTORED SNOW LOAD

$(w_f)_L = 1.50\ S = 1.50(1.2\ kPa)$

$(w_f)_L = \underline{1.8\ kPa}$

Concentrated Live Load

CONCENTRATED WHEEL LOADS (kN) — CSA CAN3-S6 M78

NOTES:

(i) THE DESIGN VEHICLE USED FOR LOAD DESIGN VALUES IS CLASSIFIED AS MS200 - 77 — 5.1.5

(ii) THE WHEEL SPACING AND AXLE LOADINGS ARE SHOWN IN APPENDIX A

(iii) THE IMPACT LOAD FRACTION IS DEVELOPED USING CLAUSE 5.1.11

CALCULATE IMPACT LOAD FRACTION — 5.1.11

$$I = \frac{15}{L + 38} \quad \text{BUT} \quad I \le 0.3$$

L = 2.44 m AS PER CASE (c)

$$I = \frac{15}{2.44 + 38} = 0.31$$

$$\therefore \quad I = \underline{0.30}$$

Uniform Dead Load

<u>Infrastructure Dead Load (kPa)</u>

DPW

Notes:

(i) The Department of Public Works has reccommended a uniform deck dead load of 400 lb/ft^2 to account for necessary infrastructure.

$\omega_{d_1} = 400 \text{ lb/ft}^2 \simeq 20 \text{ kPa}$

Calculate Factored Infrastructure Dead Load

$(\omega_f)_{d_1} = 1.25\,(20 \text{ kPa}) = \underline{25 \text{ kPa}}$

<u>Self - Weight of Concrete Deck Slab</u>

Notes:

(i) As an initial estimate assume that the weight of the deck is 15% of the total uniform load

$\therefore \omega_{d_2} = 0.15\,(1.2 \text{ kPa} + 20 \text{ kPa}) = 3.18 \text{ kPa}$

Calculate Factored Deck Slab Load

$(\omega_f)_{d_2} = 1.25\,(3.18 \text{ kPa}) \simeq \underline{4.0 \text{ kPa}}$

4.0 STRUCTURAL ANALYSIS

LOAD DISTRIBUTION & ANALYSIS

Bending Moment

CONCENTRATED WHEEL LOAD

CSA CAN3-S6 M78

NOTES:

(i) FOR PURPOSES OF ANALYSIS AND DESIGN THE WHARF DECK CAN BE CONSIDERED TO ACT AS A ONE-WAY SLAB. JUSTIFICATION FOR ONE-WAY SLAB ANALYSIS IS ILLUSTRATED IN APPENDIX D.

(ii) DUE TO THE DEGREE OF ACCESSIBILITY OF THE DESIGN VEHICLE ON APPROACH TO THE MARGINAL WHARF, THE REINFORCEMENT IN BOTH DIRECTIONS WILL BE DESIGNED AS CASE A. 5.2.3.3

(iii) ALTHOUGH THE DECK ACTS AS A ONE-WAY SLAB, TRANSVERSE REINFORCEMENT IS NECESSARY TO PROVIDE FOR LATERAL DISTRIBUTION OF THE CONCENTRATED WHEEL LOADS

(iv) THE REAR WHEEL AXLE LOAD SHALL BE INCREASED BY THE IMPACT LOAD FRACTION FOR BENDING MOMENT ANALYSIS

$$M = 0.8\,\frac{(S + 0.6)P}{10}$$

$$P = 0.4\,W = 0.4\,(200\ kN)$$

$$P = 80\ kN$$

FACTOR AXLE LOAD BY IMPACT FRACTION, I — 5.2.3.3

$$P = (1+I)P = (1.+0.3)(80\ kN)$$
$$P = 104\ kN$$

$$M = 0.8\ \frac{(2.44_m + 0.6)}{10}\ 104 \times 10^3\ N$$

$$M = 25293\ N \cdot m/m \simeq \underline{25.3\ kN \cdot m/m}$$

FACTORED UNIFORM LINE LOAD

NOTES:

(i) THE FACTORED UNIFORM LINE LOAD SHALL BE CALCULATED BY ANALYZING THE ONE-WAY SLAB IN ONE METRE STRIPS — THADANI

(ii) LOAD TRANFER OCCURS IN A DIRECTON TRANSVERSE TO THE PILE CAPS, AND THIS SPAN IS CONSIDERED THE DESIGN STRIP. TYPICALLY, WITH WHARF STRUCTURES, THIS SPAN ALSO PRODUCES MAXIMUM BENDING STRESSES AS IS THE CASE HERE

FACTORED LOADS = FACTORED DEAD LOADS + FACTORED LIVE LOADS

$$(\omega_f)_{LINE} = 1m * [(\omega_f)_{d_1} + (\omega_f)_{d_2} + (\omega_f)_L]$$

$$(\omega_f)_{LINE} = 1m * [25\ kPa + 4\ kPa + 1.8\ kPa]$$

$$(\omega_f)_{LINE} \simeq \underline{31\ kN/m}$$

CALCULATE THE BENDING MOMENTS IN THE DESIGN SPAN DUE TO THE UNIFORM LINE LOAD.

NOTES:

(i) WHEN THE LOADING IS UNIFORM AND THE SPANS ARE RELATIVELY SHORT, THE EXTRA LABOUR OF USING PARTIAL SPAN ANALYSIS FOR THE BENDING MOMENT ENVELOPE IS USUALLY NOT JUSTIFIED. FOR THIS CASE IT IS NOT CONSIDERED NECESSARY TO USE PARTIAL SPAN ANALYSIS. — WANG p.269

(ii) THE TECHNIQUE OF MOMENT DISTRIBUTION, AS OUTLINED IN CHAPTER 10 OF WANG AND SALMON, SHALL BE APPLIED TO DETERMINE THE BENDING MOMENT DIAGRAM FOR THE DESIGN SPANS IN THE LONGITUDINAL DIRECTION OF THE WHARF. — WANG CH.10

(iii) THE MODIFIED STIFFNESS METHOD WILL BE UTILIZED SO THAT THE MOMENT DISTRIBUTION PROCESS IS GREATLY SPEEDED. THIS TECHNIQUE ACCOUNTS FOR HINGED SUPPORTS. — WANG p.316 318

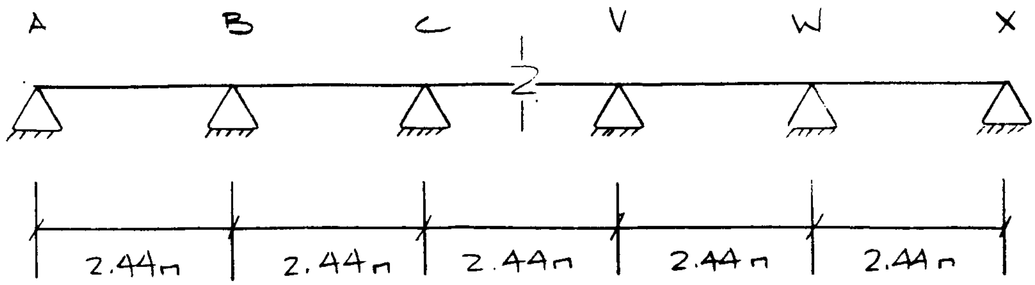
(iv) A CHECK ON MOMENT DISTRIBUTION MAY BE MADE BY EVALUATING THE SLOPES AT EACH SIDE OF A ROTATED JOINT TO SHOW THAT THEY ARE THE SAME. THE TECHNIQUE OUTLINED IN SECTION 10.7 ON PAGE 318 OF WANG AND SALMON SHALL BE USED. — WANG p.318 324

(v) FOR ALL INTERIOR SUPPORTS SUBJECT TO UNIFORM LOADING, THE BENDING MOMENTS ARE IDENTICAL GIVEN THE SAME FRAME STIFFNESS. THUS BY USING THIS PROPERTY AND THE LAWS OF SYMMETRY, ONLY ONE INTERIOR SUPPORT NEEDS TO BE CHECKED.

SUBJECT: STRUCTURAL ANALYSIS	PAGE NO. 15	DATE DEC 4/87
DESIGNED BY: SHAWN KENNY	CHECKED BY: (RP)	REFERENCE

WANG CH. 10

MOMENT DISTRIBUTION FOR UNIFORM LINE LOAD



DESIGN FRAME FOR MOMENT DISTRIBUTION ANALYSIS

*CALCULATE STIFFNESS FACTORS

$$K_{AB} = K_{WX} = \frac{3}{4}\left(\frac{1}{L}\right) = \frac{3}{4}\left(\frac{1}{2.44m}\right) = 0.3074$$

$$K_{BC} = K_{CV} = K_{VW} = \frac{1}{L} = \frac{1}{2.44m} = 0.4098$$

CALCULATE DISTRIBUTION FACTORS

$DF_{AB} = DF_{XW} = 1.0 \rightarrow$ ALL END PIN CONNECTIONS

$$DF_{BA} = DF_{WX} = \frac{0.3074}{0.3074 + 0.4098} = 0.43$$

$$DF_{BC} = DF_{WV} = 1 - DF_{BA} = 1 - DF_{EF} = 1 - 0.43 = 0.57$$

$$DF_{CB} = DF_{VW} = DF_{CD} = DF_{VC} = \frac{0.4098}{0.4098 + 0.4098} = 0.50$$

* EI IS CONSTANT
CV IS ANY INTERIOR SPAN

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CARRY OVER FACTORS

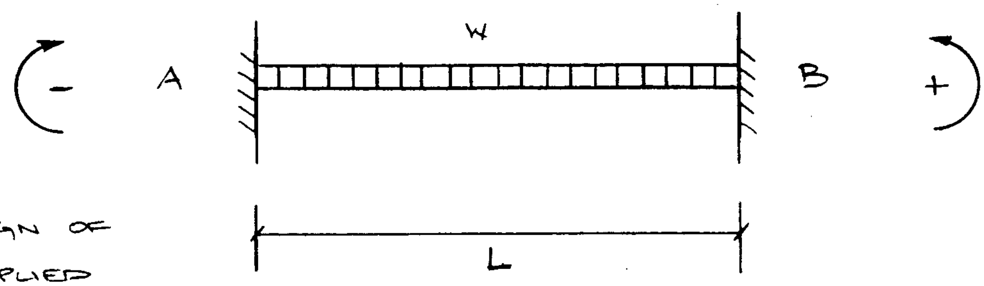
WANG CH. 10

FOR ALL INTERIOR SUPPORTS THE CARRY OVER FACTOR IS 0.5.
FOR ALL EXTERNAL JOINTS THE CARRY OVER FACTOR IS 0.0 AFTER THE MODIFIED FIXED END MOMENTS HAVE BEEN DETERMINED.

FIXED END MOMENTS

A TABLE OF FIXED END (POSITIVE CLOCKWISE) MOMENTS IS PRESENTED ON PAGE 292 OF WANG AND SALMON TEXTBOOK.

WANG p. 292



SIGN OF APPLIED MOMENT

$$M_{FAB} = -\frac{wL^2}{12}$$

$$M_{FBA} = +\frac{wL^2}{12}$$

WHERE, W - UNIFORM LINE LOAD (kN/m)
L - SPAN LENGTH (m)

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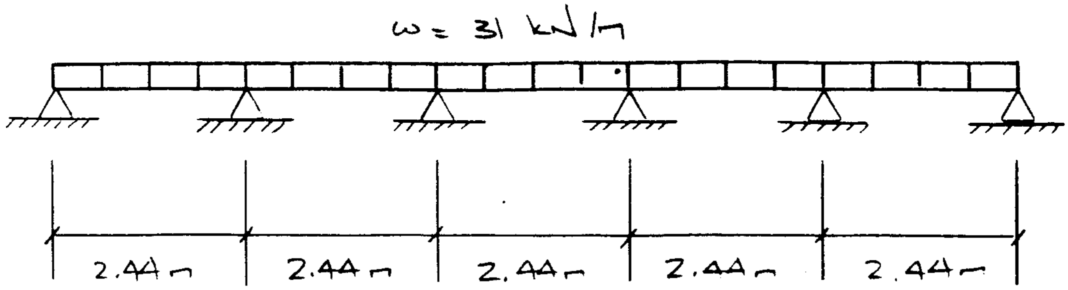
WANG CH. 10



	A		B		C		Y		W	X
STIFFNESS, K	0.3074		0.4098		0.4098		0.4098		0.3074	
DIST. FACTOR	1.0	0.43	0.57	0.5	0.5	0.5	0.5	0.57	0.43	1.0
FEM	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4
	+15.4 →	+7.7							-7.7	-15.4
MODIFIED FEM	0	+23.1	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4	-23.1	0
BALANCE	0	-3.3	-4.4	0	0	0	0	+4.4	+3.3	0
CARRY OVER	0	0	0	-2.2	0	0	+2.2	0	0	0
BALANCE	0	0	0	+1.1	+1.1	-1.1	-1.1	0	0	0
CARRY OVER	0	0	+0.6	0	-0.6	+0.6	0	-0.6	0	0
BALANCE	0	-0.3	-0.3	+0.3	+0.3	-0.3	-0.3	+0.3	+0.3	0
CARRY OVER	0	0	+0.2	-0.2	-0.2	+0.2	+0.2	-0.2	0	0
TOTAL MOMENT	0	+19.5	-19.3	+14.4	-14.8	+14.8	-14.4	+19.3	-19.5	0

COMPUTE CHECK ON MOMENT DISTRIBUTION ANALYSIS

CHANGE MOM.	+15.4	+4.1	-3.9	-1.0	+0.6	-0.6	+1.0	+3.9	-4.1	-15.4
-1/2 CHANGE	-2.1	-7.7	+0.5	+2.0	+0.3	-0.3	-2.0	-0.5	+7.7	+2.1
SUM	+13.3	-3.6	-3.4	+1.0	+0.9	-0.9	-1.0	+3.4	+3.6	-13.3
3EI/L	1.23EI		1.23EI		1.23EI		1.23EI		1.23EI	
$\theta = \frac{SUM}{3EI/L}$	+10.8/EI	-2.9/EI	-2.8/EI	+0.8/EI	+0.7/EI	-0.7/EI	-0.8/EI	+2.8/EI	+2.9/EI	-10.8/EI
		✓		✓		✓		✓		

HENCE THE MOMENT DISTRIBUTION ANALYSIS WAS PERFORMED CORRECTLY.

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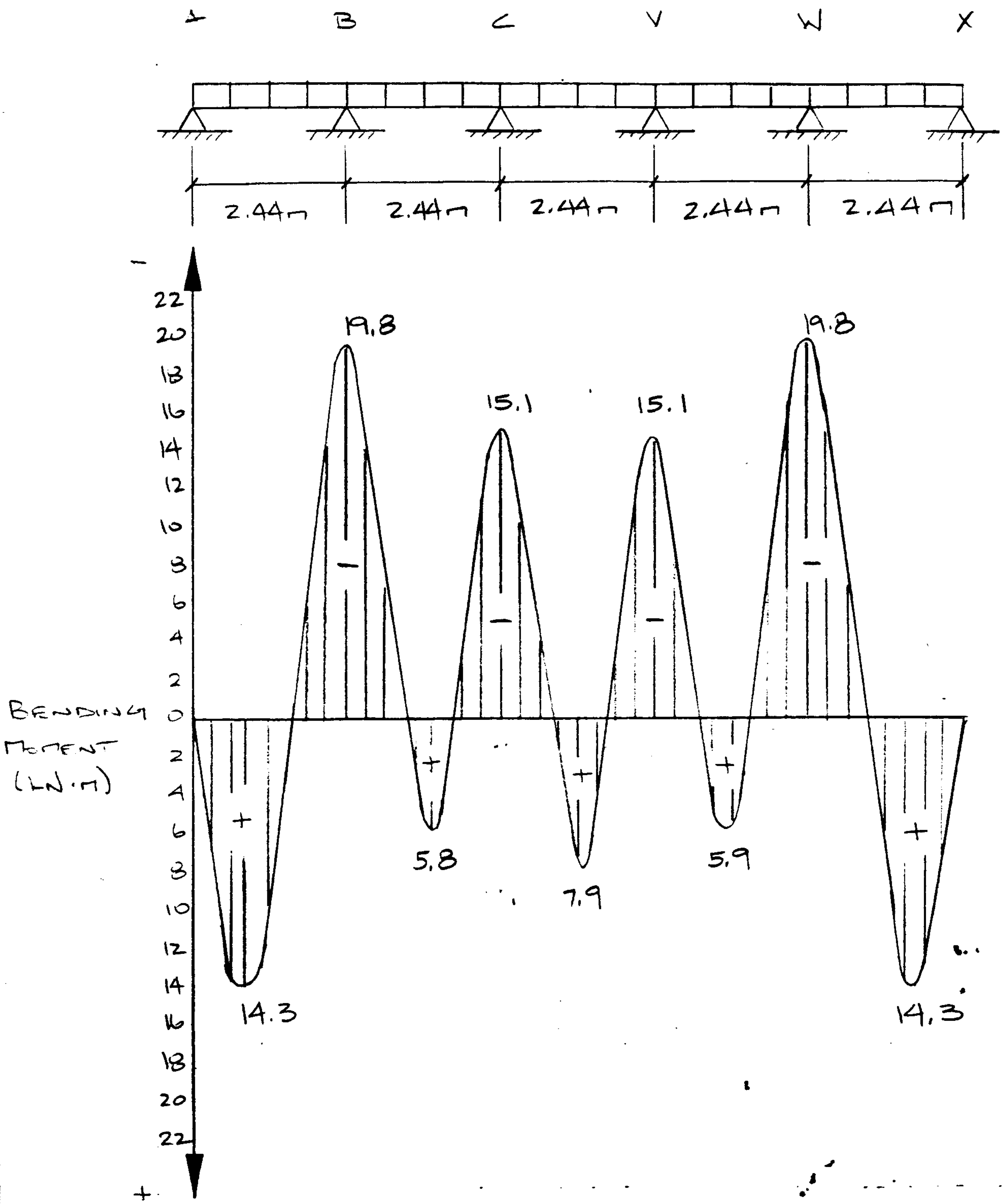
DRAW THE BENDING MOMENT DIAGRAM



∴ MAXIMUM BENDING MOMENT FOR DESIGN IS

M_{MAX} = 19.8 kN·m = <u>20 kN·m</u>

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Shear Force

CONCENTRATED WHEEL LOAD

NOTES :

(i) THE TECHNIQUE OF MOMENT DISTRIBUTION SHALL BE APPLIED TO COMPUTE THE MAX. SHEAR FORCE IN THE SLAB DUE TO CONCENTRATED WHEEL LOADS.

(ii) NOTES (ii), (iii), (iv) AND (v) ON PAGE 14 ARE ALSO APPLICABLE IN THIS CASE

(iii) THE DESIGN TRUCK USED FOR SHEAR CALCULATIONS HAS A WHEELBASE FROM THE MIDDLE WHEEL GROUP TO REAR GROUP OF 16' OR 4.88 m. SEE FIGURE

(iv) THE MAXIMUM POSITIVE OR NEGATIVE SHEAR FOR ANY POINT EXCEPT AT THE ENDS OF A SPAN WILL OCCUR UNDER PARTIAL LOADING. THE ABSOLUTE MAXIMUM SHEAR WILL OCCUR WHEN THE WHEEL LOADS ARE AT AN INFINITESIMAL DISTANCE FROM ANY SUPPORT SUPPORT — WANG p. 273

FACTORED UNIFORM LINE LOAD

(i) THE FACTORED UNIFORM LINE LOAD SHALL BE DISTRIBUTED ACROSS THE ENTIRE FRAME. THE SHEAR FORCE DIAGRAM DUE TO THE UNIFORM LOAD AND CONCENTRATED WHEEL LOADS SHALL BE ANALYZED AT THE SAME TIME USING MOMENT DISTRIBUTION. NOTES (ii), (iii), (iv) AND (v) ON PAGE 14 ARE ALSO APPLICABLE.

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MOMENT DISTRIBUTION FOR SHEAR FORCE

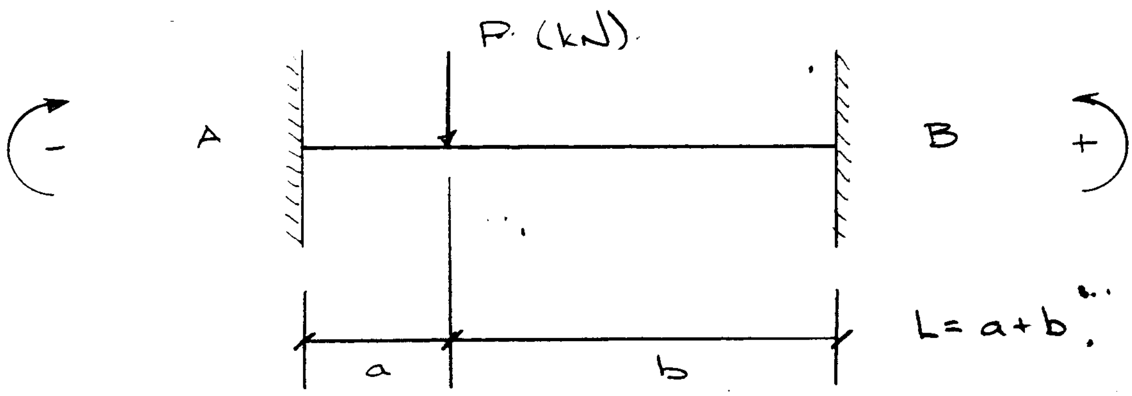
NOTES :

(i) SPAN $\overline{GV}$ HAS THE SAME LOADING PATTERN, SHEAR FORCE AND BENDING MOMENT DIAGRAM; DUE TO SYMMETRY

(ii) THE STIFFNESS, DISTRIBUTION, AND CARRY OVER FACTORS ARE IDENTICAL TO THOSE AS PREVIOUSLY CALCULATED FOR SIMILAR SPANS

(iii) THE FIXED END MOMENTS FOR THE UNIFORMLY DISTRIBUTED LOAD ARE THE SAME AS PREVIOUSLY CALCULATED.

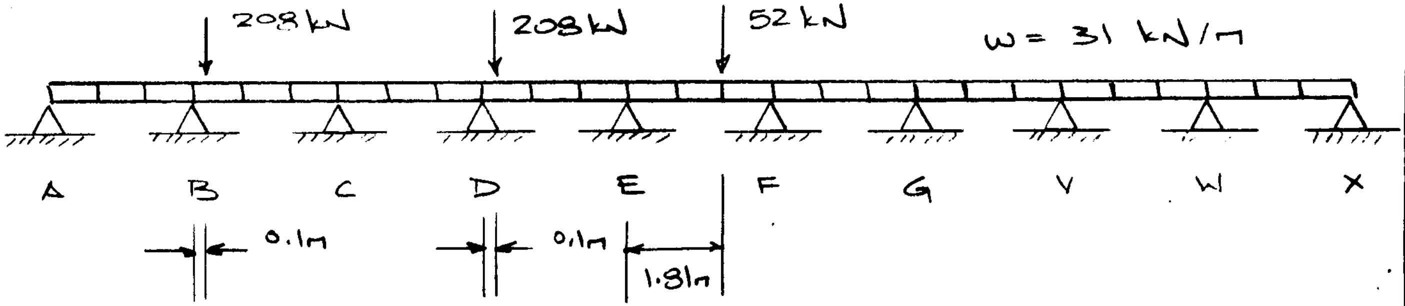
CALCULATE FIXED END MOMENTS FOR POINT LOADS — HIBBELER



$L = a + b$

$$M_{FAB} = \frac{Pb^2a}{L^2}$$

$$M_{FBA} = \frac{Pa^2b}{L^2}$$



	AB		BC		CD		DE		EF		FG		GV		VW		WX	
STIFFNESS, K	0.3074		0.4098		0.4098		0.4098		0.4098		0.4098		0.4098		0.4098		0.3074	
DIST. FACTOR	1.0	0.43	0.57	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.57	0.43	1.0
FEM	-15.4	+15.4	-17.4	+15.4	-15.4	+15.4	-17.4	+15.4	-21.7	+33.4	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4
	+15.4 →	+7.7															-7.7 ←	-15.4
MODIFIED FEM	0	+23.1	-17.4	+15.4	-15.4	+15.4	-17.4	+15.4	-21.7	+33.4	-15.4	+15.4	-15.4	+15.4	-15.4	+15.4	-23.1	0
BALANCE	0	-2.5	-3.2	0	0	+1.0	+1.0	+3.2	+3.2	-9.0	-9.0	0	0	0	0	+4.4	+3.3	0
CARRY OVER	0	0	0	-1.6	+0.5	0	+1.6	+0.5	-4.5	+1.6	0	-4.5	0	0	+2.2	0	0	0
BALANCE	0	0	0	+0.6	+0.6	-0.8	-0.8	+2.0	+2.0	-0.8	-0.8	+2.2	+2.2	-1.1	-1.1	0	0	0
CARRY OVER	0	0	+0.3	0	-0.4	+0.3	+1.0	-0.4	-0.4	+1.0	+1.1	-0.4	-0.6	+1.1	0	-0.6	0	0
BALANCE	0	-0.1	-0.2	+0.2	+0.2	-0.2	-0.2	-0.4	-0.4	-1.0	-1.0	+0.5	+0.5	-0.6	-0.6	+0.3	+0.3	0
CARRY OVER	0	0	+0.1	-0.1	-0.1	+0.1	-0.2	-0.1	-0.5	-0.2	+0.3	-0.5	-0.3	+0.3	+0.2	-0.3	0	0
TOTAL MOMENT	0	+20.5	-20.4	+14.5	-14.6	+15.8	-15	+20.2	-22.3	+25	-24.8	+12.7	-13.6	+15.1	-14.7	+19.2	-19.5	0
CHANGE MOMENT		-2.6	-3	-0.9	+0.8	+0.4	+2.4	+5.2	-1.6	-8.4	-9.4	-2.7	+1.8	-0.3	+0.7	+3.8	+3.6	
-1/2 CHANGE		-7.7	0.5	1.5	-0.2	-0.4	-2.6	-1.2	4.2	0.8	+1.4	4.7	0.2	-0.9	-1.9	-0.4	7.7	-
SUM		-10.3	-2.5	0.6	0.6	0	-0.2	4.0	2.6	-7.6	-8	+2.0	2.0	-1.2	-1.2	+3.4	11.3	
3EI / L	1.23EI		1.23EI		1.23EI		1.23EI		1.23EI		1.23EI		1.23EI		1.23EI		1.23EI	
θ = SUM / (3EI/L)				0.43/EI	0.43/EI	0	0.16/EI	3.25/EI	2.1/EI	-6.2/EI	-6.5/EI	1.6/EI	1.6/EI	0.98/EI	0.98/EI	2.76/EI		

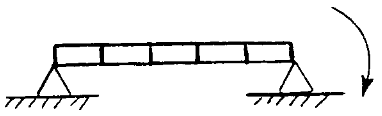
Wang f. 10

SUBJECT: STRUCTURAL ANALYSIS
DESIGNED BY: SHAWN KENNY
CHECKED BY: [illegible]
PAGE NO. 21
DATE Dec 4/97
REFERENCE

Analyze Single Spans for Shear Force Diagram

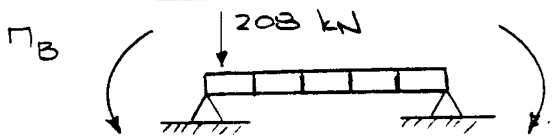
Span AB

$M_B = 20.5$ kN·m



A	B	
↑ 37.8	↑ 37.8	Simple Support Rxns
↓ 8.4	↑ 8.4	Couple Rxn
29.4	46.2	Total Rxn

Span BC

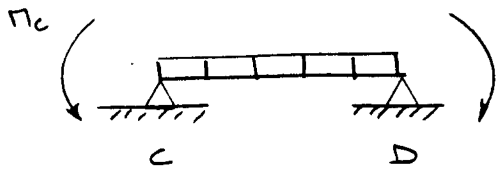


B	C	
↑ 245	↑ 38.7	Simple Support Rxns
↑ 2.4	↓ 2.4	Couple Rxn
247.4	36.3	Total Rxn

SUBJECT: STRUCTURAL ANALYSIS | PAGE NO. 23 | DATE DEC 4/37

DESIGNED BY: SHAWN KENNY | CHECKED BY: RJ | REFERENCE

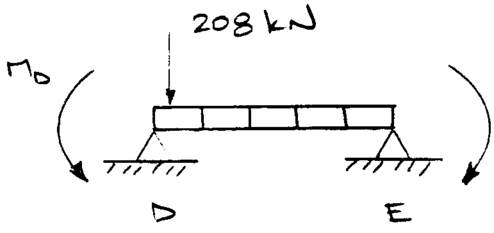
SPAN CD



$M_D = 15.8$ kN·m

C	D	
↑ 37.8	↑ 37.8	SIMPLE SUPPORT RXNS
↓ 0.5	↑ 0.5	COUPLE RXNS
37.3	38.3	TOTAL RXN

SPAN DE



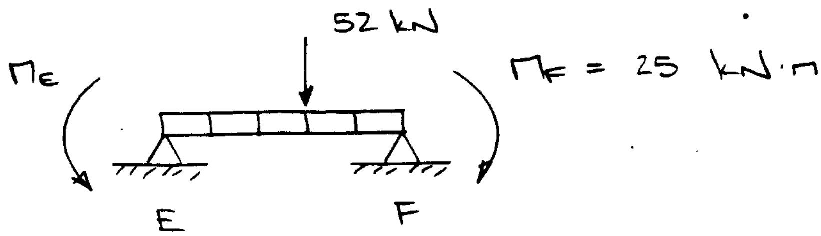
$M_E = 22.3$ kN·m

D	E	
↑ 245	↑ 38.7	SIMPLE SUPPORT RXNS
↓ 2.7	↑ 2.7	COUPLE RXNS
242.3	41.4	TOTAL RXN

SUBJECT: STRUCTURAL ANALYSIS	PAGE NO. 24	DATE DEC 4/87

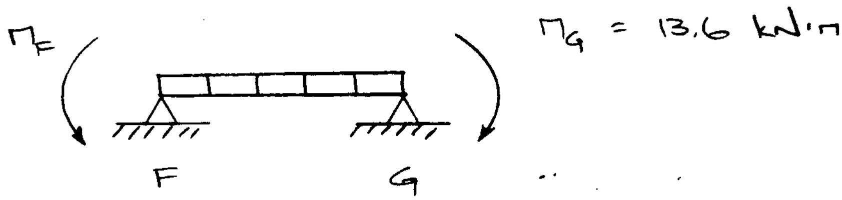
DESIGNED BY: SHAWN KENNY	CHECKED BY: RC		REFERENCE

SPAN EF



E	F	
↑ 51.2	↑ 76.4	SIMPLE SUPPORT RXN
↓ 1.1	↑ 1.1	COUPLE RXN
50.1	77.5	TOTAL RXN

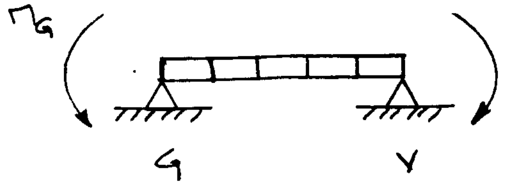
SPAN FG



F	G	
↑ 37.8	↑ 37.8	SIMPLE SUPPORT RXNS
↑ 4.7	↓ 4.7	COUPLE RXN
42.5	33.1	TOTAL RXN

SUBJECT: Structural Analysis	PAGE NO. 25	DATE Dec 4/87
DESIGNED BY: Shawn Kenny	CHECKED BY: RT	REFERENCE

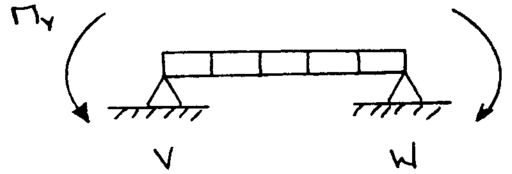
Span GV



$M_V = 15.1$ kN·m

G	V	
↑ 37.8	↑ 37.8	Simple Support Rxns
↓ 0.6	↑ 0.6	Couple Rxn
37.2	38.4	Total Rxn

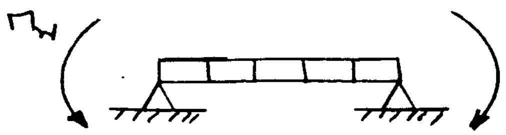
Span VW



$M_W = 19.5$ kN·m

V	W	
↑ 37.8	↑ 37.8	Simple Support Rxns
↓ 1.8	↑ 1.8	Couple Rxn
36	39.6	Total Rxn

SPAN WX



37.8 ↑	37.8 ↑	SIMPLE SUPPORT RXNS
8 ↑	8 ↓	COUPLE RXN
45.8	29.8	TOTAL RXN

TABLE

SUPPORT JOINT	JOINT RXN (kN)
A	29.4
B	293.6
C	73.6
D	280.6
E	91.2
F	120.0
G	70.3
Y	74.4
W	85.4
X	29.8

Subject: Structural Analysis

Designed by: Shawn Kenny

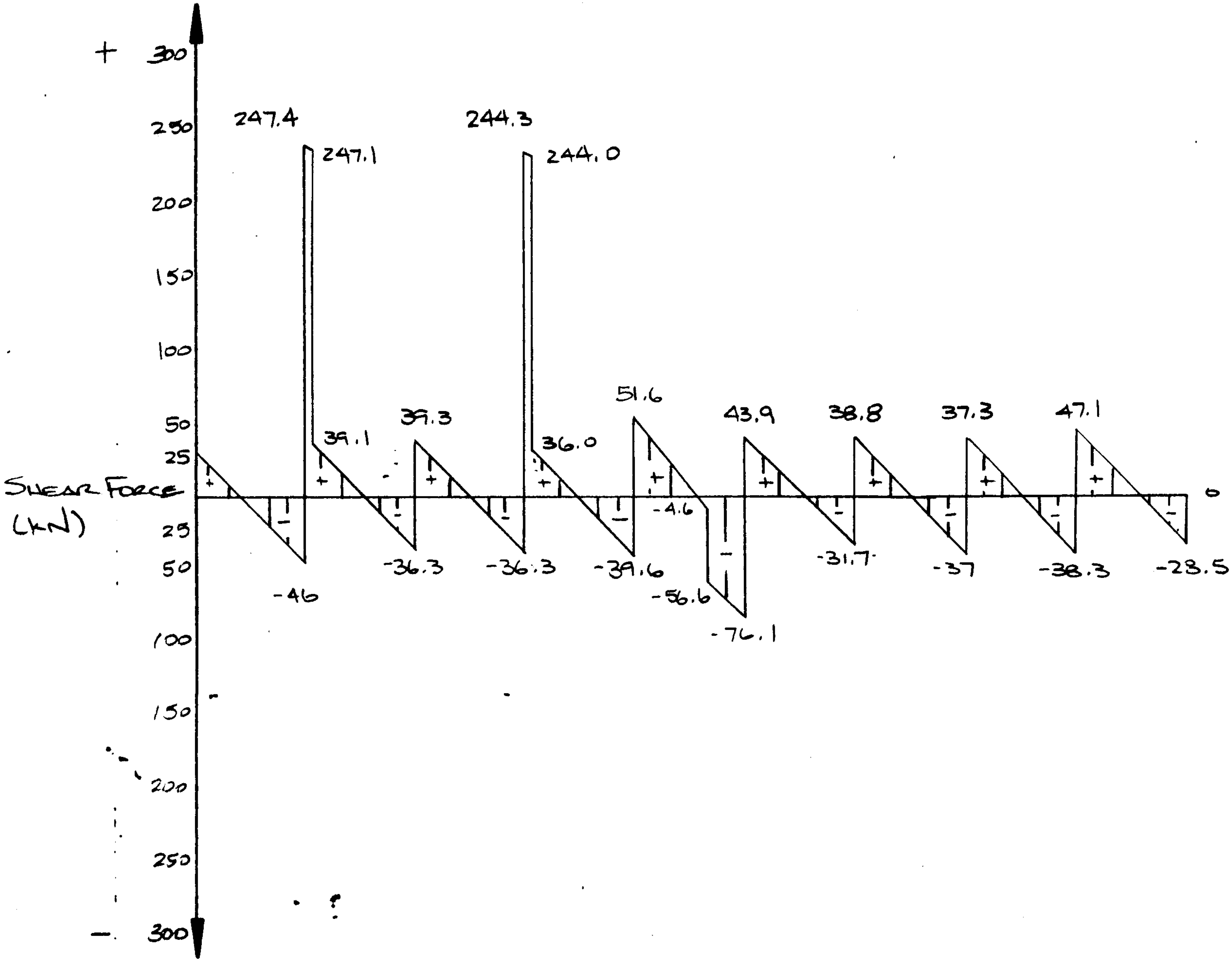
Checked by: RC

Page No. 27

Date Dec 4/97

Reference

Draw the Shear Force Diagram



5.0 DESIGN OF CONCRETE SLAB

DESIGN FOR FLEXURAL RESISTANCE

General

MAXIMUM BENDING MOMENT FOR DESIGN

NOTES :

(i) AS PREVIOUSLY STATED THE FLEXURAL REINFORCEMENT SHALL BE DESIGNED BASED ON THE ABSOLUTE MAXIMUM BENDING MOMENT IN THE SLAB, AND THE REINFORCEMENT SHALL BE EQUALLY DISTRIBUTED IN THE LONGITUDINAL AND TRANSVERSE DIRECTIONS.

(ii) THE ABSOLUTE MAXIMUM BENDING MOMENT IS COMPOSED OF THE MOMENT DUE TO THE CONCENTRATED WHEEL LOADS AND THE TOTAL UNIFORM LINE LOAD (i.e. DEAD PLUS LIVE)

$$M_{MAX} = 25.3 \text{ kN·m/m} + 20 \text{ kN·m/m}$$

$$M_{MAX} = 45.3 \text{ kN·m/m}$$

(iii) THE DESIGN SPAN IS 2440 mm, MEASURED FROM CENTRE TO CENTRE OF THE PILE CAP SUPPORTS.

(iv) ANALYSIS WILL BE BASED ON 1 METRE STRIPS

SUBJECT: DESIGN OF CONCRETE SLAB	PAGE NO. 30	DATE

DESIGNED BY:	CHECKED BY: RT		REFERENCE

CALCULATE MINIMUM THICKNESS OF DESIGN SLAB — CSA CAN3-S6 M78

$$d = \frac{S + 3000}{30}$$; S IS DEFINED IN CLAUSE 8.4.1A

$$d = \frac{2440 + 3000}{30} = 181 \text{ mm}$$

$$\therefore d = \underline{200 \text{ mm}}$$

THE CLEAR COVER FOR REINFORCEMENT SHALL BE 50 mm AS PER CLAUSE 8.2.3.1 (b)(i). ALSO, IT SHOULD BE NOTED THAT THE METAL FORMED DECKING OFFERS SOME PROTECTION FROM THE CORROSIVE ENVIRONMENT.

HENCE THE EFFECTIVE DEPTH, ASSUMING #20M BARS ARE USED IS;

$$d' = 200\text{ mm} - 50\text{ mm} - 20 - \tfrac{1}{2}(20)$$
$$d' = \underline{120 \text{ mm}}$$

CALCULATE THE RESISTANCE FACTOR, K_r (MPa) — CPCA

NOTE: THE TABLE USED CAN BE FOUND IN APPENDIX B.

$$K_r = \frac{M_f \times 10^6}{b d'^2}$$

$$K_r = \frac{45.3 \times 10^6}{(1000 \text{ mm})(120 \text{ mm})^2} = 3.15 \text{ MPa}$$

THE REQUIRE REINFORCEMENT RATIO, ρ, FOR 30 MPa CONCRETE IS . — CPCA

$$\rho = 1.05\ \% = 0.0105$$

THE AREA OF STEEL REQUIRED IS

$$A_s = \rho b d' = 0.0105\ (1000\ mm)(120\ mm)$$
$$A_s = 1260\ mm^2/m$$

USING CLAUSE 8.2.4.3, THE MINIMUM AREA OF STEEL REQUIRED IS — CSA CAN3-S6 M78

$$A_{s_{MIN}} = 0.002\ A_g = 0.002\ (1000\ mm)(200\ mm)$$

$$A_{s_{MIN}} = 400\ mm^2/m$$

$\therefore$ USE $A_s = \underline{1260\ mm^2/m}$

Spacing of Reinforcement — CSA CAN3-S6 M78

NOTES:

(i) CLAUSE 8.2.2 GOVERNS THE ALLOWABLE SPACING FOR FLEXURE REINFORCEMENT

(ii) IN PARTICULAR, CLAUSES 8.2.2.1, 8.2.2.7 AND 8.2.2.9 ARE APPLICABLE

SUBJECT: DESIGN OF CONCRETE SLABS	PAGE NO. 32	DATE DEC 4/87
DESIGNED BY: SHAWN KENNY	CHECKED BY: RT	REFERENCE

THE FLEXURAL REINFORCEMENT SHALL NOT BE SPACED FURTHER APART THAN THE LESSER OF

① 1.5 SLAB THICKNESS → 1.5(185) = 278 mm

② 450 mm

CSA CAN3-S6 M78 8.2.2.7

FIND THE NUMBER OF BARS PER METRE

$$\#bars = \frac{A_s}{A_b} = \frac{1260\ mm^2/m}{300\ mm^2/bar} = 4.2 = 5\ \frac{bars}{m}$$

∴ USE 5 # 20M @ 200 mm C-C SPACING

DEVELOPMENT LENGTH

Positive Moment Reinforcement

CSA CAN3-S6 M78 8.3.1.

NOTE:

(i) ALL POSITIVE MOMENT REINFORCEMENT SHALL BE RUN THROUGH THE SUPPORTS, AS THE REQUIRED EMBEDEMENT LENGTH AND INFLECTION POINTS ARE OF EQUAL MAGNITUDE.

MAX. DISTANCE FOR POINT OF INFLECTION FROM SUPPORT IS 400 mm

EMBEDEMENT LENGTH REQUIREMENT BY CODE IS $12 d_b = 12 * (20) = 240$ mm

SUBJECT: DESIGN OF CONCRETE SLAB	PAGE NO. 33	DATE DEC 4/87
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Negative Moment Reinforcement

CSA CAN3-S6 M78

NOTES :

(i) THE REINFORCING BARS OVER THE SUPPORT ~~SHALL~~ CONSIST OF EVERY ALTERNATE POSITIVE MOMENT REINFORCING BAR BENT; AS PER CLAUSE 8.3.1.2.1

(ii) THE REMAINING NEGATIVE REINFORCEMENT SHALL BE #20 M BARS AT 200 mm SPACING;

CALCULATE THE REQUIRED DEVELOPMENT LENGTH FOR NEGATIVE REINFORCEMENT. 8.3.1.3.3

$$l_d = \text{GREATER OF} \begin{cases} d' \\ 12\, d_b \\ 1/16\, L_n \end{cases}$$

$$l_d = \text{GREATER OF} \begin{cases} 120 \text{ mm} \\ 240 \text{ mm} \\ 1/16\,(2440) = 153 \text{ mm} \end{cases}$$

$$\therefore\ l_d = \underline{240 \text{ mm}}$$

HENCE, THE NEGATIVE REINFORCEMENTS EXTENDS FROM THE CENTER OF EACH SUPPORT ON EITHER SIDE BY

$$\text{bar length} = 240\text{mm} + 400\text{mm} = \underline{640 \text{ mm}}$$

CSA CAN3-S6 M78

DESIGN FOR SHEAR RESITANCE

Permissible Shear Stress

COMPUTE THE DESIGN SHEAR STRESS

$$v_u = \frac{V_u}{\phi b_w d}$$ CLAUSE 3.6.6.1.1

$$v_u = \frac{247.4 \times 10^3 \text{ N}}{(0.85)(1000 \text{ mm})(120 \text{ mm})}$$

$$v_u = 2.43 \frac{\text{N}}{\text{mm}^2} = 2.43 \text{ MPa}$$

ALLOWABLE SHEAR STRESS TO BE CARRIED BY THE CONCRETE IS

$$(v_c)_{MAX} = \frac{\sqrt{f'_c}}{3} = \frac{\sqrt{30 \text{ MPa}}}{3} = 1.83 \text{ MPa}$$

$$(v_c)_{MAX} < v_u$$

THERE ARE TWO SOLUTIONS TO INCREASE THE SHEAR STRENGTH OF THE SECTION

(i) INCREASE THE EFFECTIVE DEPTH

(ii) ADD SHEAR REINFORCEMENTS

DESIGN OF SHEAR REINFORCEMENTS

CSA CAN3-S6 M78

NOTES:

(i) THE SHEAR REINFORCEMENTS SHALL CONSIST OF BARS BENT UP AT THE SAME DISTANCE FROM SUPPORT — 8.6.6.3.2

(ii) THE AREA OF SHEAR REINFORCEMENTS IS COMPUTED AS FOLLOWS

$$(V_u - V_c) \le \frac{\sqrt{f'_c}}{4}$$

$$(2.43\ MPa - 1.83\ MPa) \le \frac{\sqrt{30}}{4}$$

$$0.6\ MPa \le 1.37\ MPa \quad \therefore \text{O.K.}$$

$$A_v = \frac{(V_u - V_c)\, b_w\, d}{f_y \sin\alpha}$$

$$A_v = \frac{(2.43\ MPa - 1.83\ MPa)(1000\ mm)(120\ mm)}{400\ MPa\ (\sin 45^\circ)}$$

$$A_v = 255\ mm^2$$

COMPUTE ULTIMATE SHEAR FORCE FOR CONCRETE WITHOUT SHEAR REINFORCEMENTS

$$V_{design} = (V_c)_{max}\, \phi\, b_w\, d$$

$$V_{design} = (1.83\ MPa)(0.85)(1.0\ m)(0.120\ m)$$

$$V_{design} = 187\ kN$$

SUBJECT: DESIGN OF CONCRETE SLAB	PAGE NO. 36	DATE DEC 4/87
DESIGNED BY: SHAWN KENNY	CHECKED BY: (RT).	REFERENCE

COMPUTE THE DISTANCE FROM THE SUPPORT THAT SHEAR REINFORCEMENT IS REQUIRED USING THE SHEAR FORCE DIAGRAM

$$x = \frac{247.4\ \text{kN} - 187\ \text{kN}}{31\ \text{kN/m}}$$

x = 1.95 m FROM THE CENTER OF SUPPORT

SUBJECT: DESIGN OF CONCRETE SLAB	PAGE NO. 37	DATE DEC 4/87
DESIGNED BY: SHAWN KENNY	CHECKED BY: RC	REFERENCE

REFERENCE: WESTEEL-ROSCO LTD.

DESIGN OF METAL DECK AS FORMWORK

NOTES :

(i) THE TECHNIQUE OF MOMENT DISTRIBUTION SHALL BE APPLIED TO COMPUTE THE MAXIMUM SHEAR FORCE AND BENDING MOMENT TO BE RESISTED BY THE METAL DECKING

(ii) NOTES (ii), (iii), (iv), AND (v) ON PAGE 14 ARE ALSO APPLICABLE.

DESIGN LOAD CALCULATIONS

SELF WEIGHT ON CONCRETE SLAB

$\gamma_c = 2400\ kg/m^3$ → NORMAL WEIGHT CONCRETE

$\gamma_c = 23.5\ kN/m^3$

Slab Thickness = Slab Depth + Fluted Depth

TRY A HI-BOND STEEL FLOOR T-30-6 WITH
*BASE STEEL THICKNESS OF 1.22 mm

Slab Thickness = 200 mm + 76 mm
= 0.276 m

* TECHNICAL DATA SHEET IS ENCLOSED IN APPENDIX C

SUBJECT:	PAGE NO.	DATE
DESIGN OF CONCRETE SLAB	38	Dec4/87

DESIGNED BY:	CHECKED BY:		REFERENCE
SHAWN KENNY	(RD).		

CALCULATE WEIGHT OF CONCRETE SLAB PER METRE WIDTH

WESTEEL ROSCO LTD

$$\omega_{slab} = (23.5\ kN/m^3)(0.276\ m)(1\ m) = 6.5\ kN/m$$

COMPUTE SELF WEIGHT OF METAL FORMED DECK, USING DATA TABLE FROM APPENDIX C.

$$\omega_{deck} = (19.18\ kg/m^2)(9.81\ m/s^2)(5.5\ m)$$

$$\omega_{deck} = 1.0\ kN/m$$

COMPUTE THE FACTORED LINE LOAD OF CONCRETE SLAB AND METAL DECK.

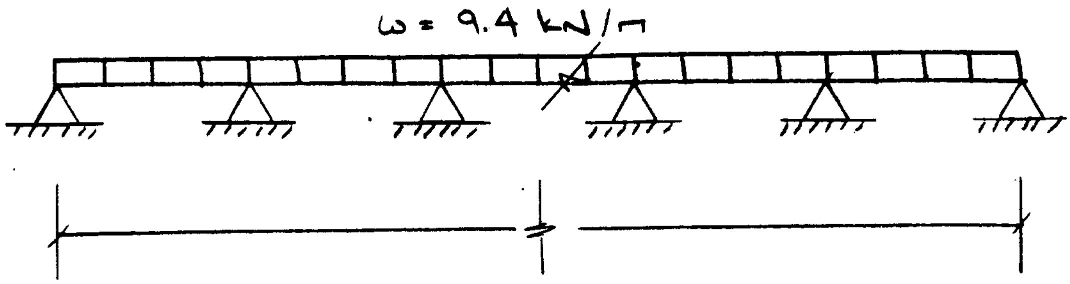
$$(\omega_f)_{line} = 1.25(6.5\ kN/m + 1.0\ kN/m)$$

$$(\omega_f)_{line} = \underline{9.38\ kN/m}$$

CALCULATE THE MAXIMUM SHEAR FORCE AND BENDING MOMENT ACTING ON THE STEEL DECK, ACTING AS A FORMWORK. THEN CHECK THE ADEQUACY OF THE SECTION...

DESIGNED BY: SHAWN KENNY | CHECKED BY: (RT)

REFERENCE: Wong Ch. 10



5 SPANS @ 2440 mm

	A		B		C		V		W	X
STIFFNESS, K	0.3074		0.4098		0.4098		0.4098		0.3074	
DIST. FACTOR	1.0	0.43	0.57	0.5	0.5	0.5	0.5	0.57	0.43	1.0
FEM	-4.7	+4.7	-4.7	+4.7	-4.7	+4.7	-4.7	+4.7	-4.7	+4.7
	+4.7 →	+2.4							-2.4	-4.7
MODIFIED FEM	0	+7.1	-4.7	+4.7	-4.7	+4.7	-4.7	+4.7	-7.1	0
BALANCE	0	-1.0	-1.4	0	0	0	0	+1.4	+1.0	0
CARRY OVER	0	0	0	-0.7	0	0	+0.7	0	0	0
BALANCE	0	0	0	+0.4	+0.4	-0.4	-0.4	0	0	0
CARRY OVER	0	0	+0.2	0	-0.2	+0.2	0	-0.2	0	0
BALANCED	0	-0.1	-0.1	+0.1	+0.1	-0.1	-0.1	+0.1	+0.1	0
TOTAL MOMENT	0	+6.0	-6.0	+4.5	-4.4	+4.4	-4.5	+6.0	-6.0	0

COMPUTE CHECK ON MOMENT DISTRIBUTION ANALYSIS

CHANGE MOM	+4.7	-1.1	-1.3	-0.2	+0.3	-0.3	+0.2	+1.3	+1.1	-4.7
-1/2 CHANGE	+0.6	-2.4	+0.1	+0.7	+0.2	-0.2	-0.7	-0.1	+2.4	-0.6
SUM	5.3	-3.5	-1.2	+0.5	+0.5	-0.5	-0.5	+1.2	+3.5	-5.3
3EI/L	1.23EI		1.23 EI		1.23EI		1.23EI		1.23 EI	
θ = SUM / 3EI/L				0.4/EI	0.4/EI	-0.4/EI	-0.4/EI			

COMPUTE SUPPORT REACTIONS DUE TO SIMPLE BEAM AND COUPLE FORCES.

SUBJECT: Design of Concrete Slab	PAGE NO. 40	DATE Dec 4/87

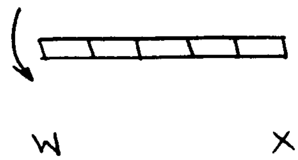
DESIGNED BY: Shawn Kenny	CHECKED BY: RP		REFERENCE

$M_B = 6.0$ kN.m $\qquad M_c = 4.5$ kN.m

	A		B	B		C
Support Rxns	↑	11.5 kN	↑	↑	11.5 kN	↑
Couple Rxns	↓	2.5 kN	↑	↑	0.6 kN	↓
Total Rxn	↑ 9.0 kN		↑ 14 kN	↑ 12.1 kN		↑ 10.9 kN

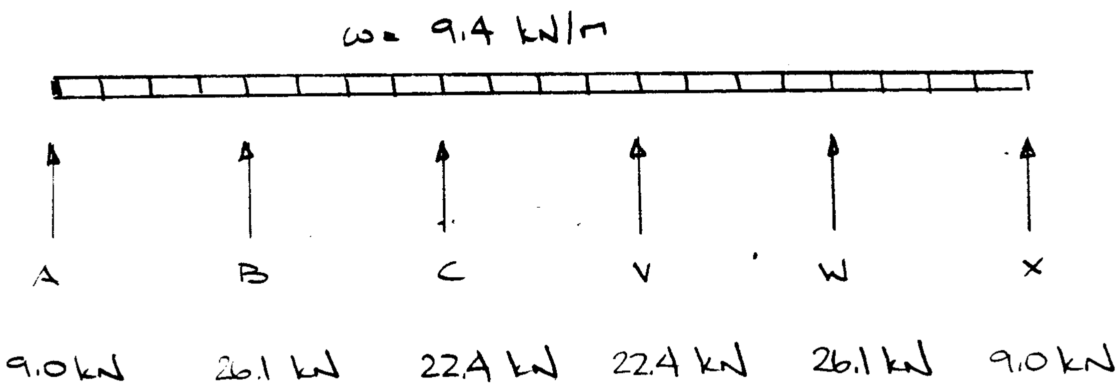
$M_V = 4.5$ kN.m $\qquad M_W = 6.0$ kN.m

	C		V	V		W
Support Rxns	↑	11.5 kN	↑	↑	11.5 kN	↑
Couple Rxns	|	0	|	↓	0.6 kN	↑
Total Rxn	↑ 11.5 kN		↑ 11.5 kN	↑ 10.9 kN		↑ 12.1 kN



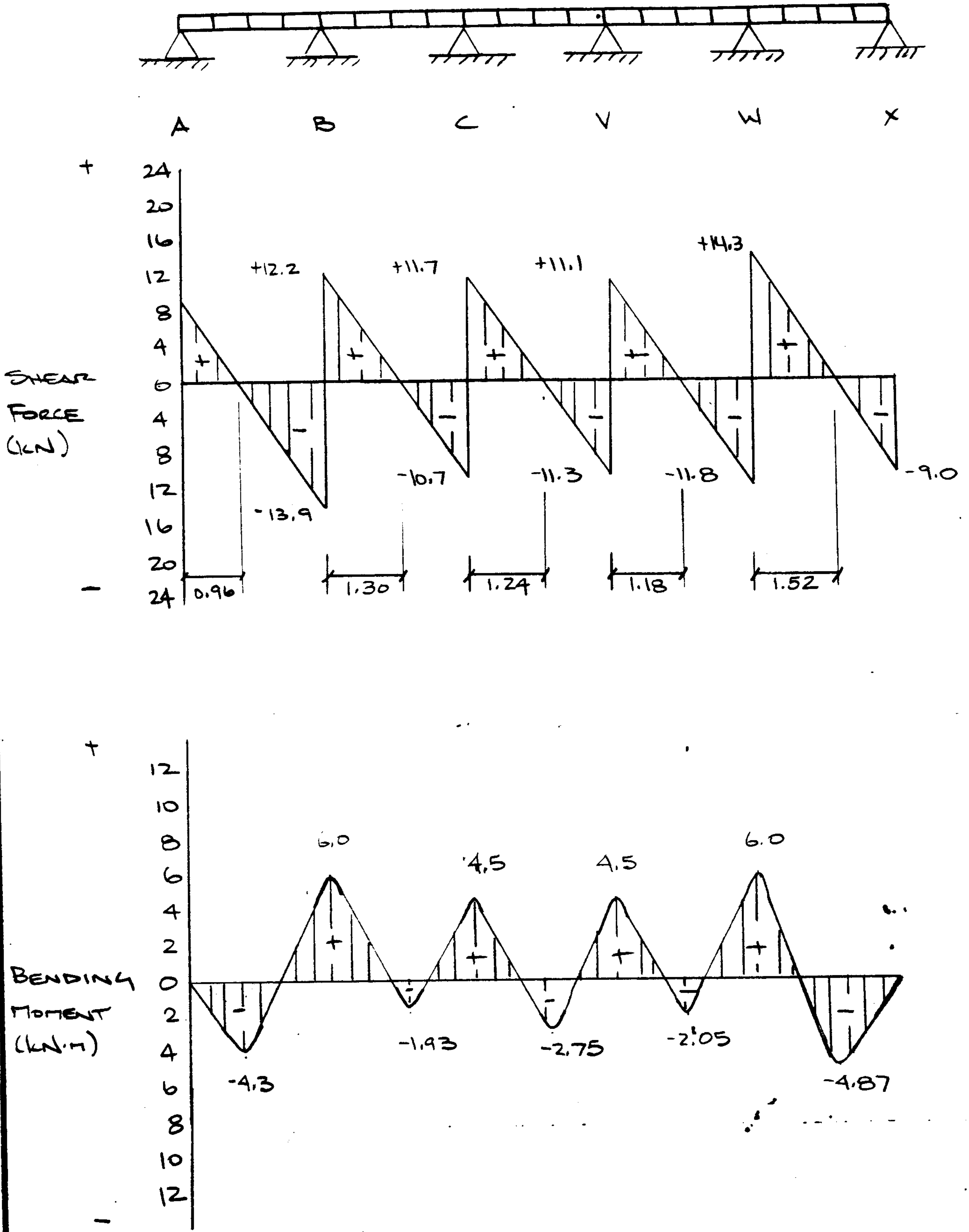
	W		X
SUPPORT RXNS	↑	11.5 kN	↑
COUPLE RXNS	↑	2.5 kN	↓
TOTAL RXN	↑ 14 kN		↑ 9.0 kN

SUPPORT REACTION SUMMARY



DRAW THE FORCE, SHEAR FORCE AND BENDING MOMENT DIAGRAMS.

SUBJECT: Design of Concrete Slab	PAGE NO. 42	DATE Dec 04/87
DESIGNED BY: Shawn Kenny	CHECKED BY: RP	REFERENCE



SUBJECT: Design of Concrete Slab	PAGE NO. 43	DATE Dec 4/87
DESIGNED BY: Shawn Kenny	CHECKED BY: (RT).	REFERENCE

Maximum Shear Force

V_{max} = <u>14.3 kN</u>

Maximum Bending Moment

M_{max} = <u>6.0 kN·m</u>

<u>Check Adequacy of Design Section</u>

Metal Deck Selected: T-30-6, with a base thickness of 1.22 mm

Check Shear Capacity

V_R = 27.7 kN (see Appendix C) — Westee[l] Rosco[e]

$V_R \geq V_{max}$ ∴ <u>O.K</u>

Check Moment Capacity

Using data from Appendix

$M_R = S\sigma = 47.23 \times 10^3\ mm^3 \left(\frac{m^3}{1000^3\ mm^3}\right)(142\ MPa)$

M_R = 6.7 kN·m

$M_R \geq M_{max}$ ∴ <u>O.K</u>

SUBJECT: DESIGN OF CONCRETE SLAB	PAGE NO. 44	DATE Dec 4/97
DESIGNED BY: SHAWN KENNY	CHECKED BY: RT	REFERENCE

CHECK ADEQUACY OF SECTION FOR DEFLECTION

(i) DEFLECTION DUE TO WEIGHT OF CONCRETE SLAB AND METAL FORMED DECK

CISC p 5-132 AND WESTEEL ROSCO

$$\Delta_o = \frac{5}{384} \frac{\omega l^4}{E I}$$

$$\Delta_o = \frac{5}{384} \frac{(7.5 \text{ N/mm})(2440 \text{ mm})^4}{(200{,}000 \text{ N/mm}^2)(2009.3 \times 10^3 \text{ mm}^4)}$$

$$\Delta_o = 8.2 \text{ mm}$$

(ii) COMPUTE PONDING FACTOR FOR DEFLECTION (see WESTEEL-ROSCO)

$$K_p = \frac{144 \, \gamma_c \, l^4}{\pi^4 E I}$$

$$K_p = \frac{144 (2400 \text{ kg/m}^3)(2.44 \text{ m})^4}{\pi^4 (200{,}000 \text{ MPa})(2.0093 \times 10^{-6} \text{ m}^4)}$$

$$K_p = 0.30$$

(iii) COMPUTE TOTAL DEFLECTION

$$\Delta_t = \Delta_o \left(\frac{1}{1 - K_p} \right)$$

$$\Delta_t = 8.2 \text{ mm} \left(\frac{1}{1 - 0.30} \right)$$

$$\Delta_t = \underline{11.7 \text{ mm}}$$

CHECK TOTAL DEFLECTION WITH ALLOWABLE

$$\Delta_t \leq \frac{l'}{180}$$

$$\frac{l'}{180} = \frac{2440\text{ mm}}{180} = 13.6\text{ mm}$$

$$11.7\text{ mm} < 13.6\text{ mm} \quad \therefore \text{ O.K.}$$

HENCE, THE DESIGN STEEL SECTION TAKEN FOR THE METAL DECKING IS ADEQUATE AND MEETS ALL REQUIREMENTS FOR DESIGN AS FORMWORK. DETAILED DESIGN SPECIFICATIONS, AND LAYOUT OF DECK WITH RESPECT TO THE WHARF IS ILLUSTRATED IN APPENDIX D.

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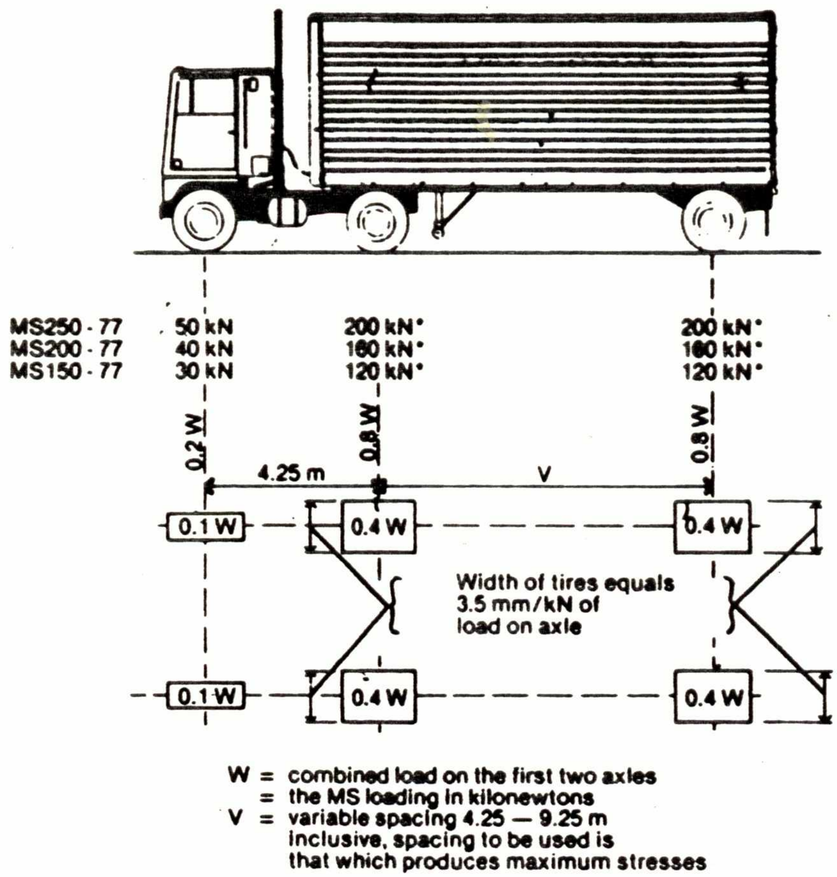
APPENDIX A
MS LOADING CONFIGURATION



MS LOADING CONFIGURATION

Source: CSA CAN3-S6-M78

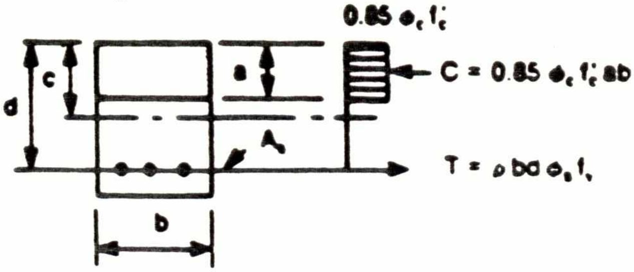
APPENDIX B
REINFORCED CONCRETE DESIGN TABLE

Rectangular Beams
Reinforcement Ratio ρ (%) for Resistance Factors K_r (MPa)
Reinforcement f_y = 400 MPa

K_r (MPa)	f'_c 20	25	30	35	40
0.5	0.15	0.15	0.15	0.15	0.15
0.6	0.18	0.18	0.18	0.18	0.18
0.7	0.21	0.21	0.21	0.21	0.21
0.8	0.25	0.24	0.24	0.24	0.24
0.9	0.28	0.27	0.27	0.27	0.27
1.0	0.31	0.31	0.30	0.30	0.30
1.1	0.34	0.34	0.34	0.33	0.33
1.2	0.38	0.37	0.37	0.37	0.36
1.3	0.41	0.40	0.40	0.40	0.40
1.4	0.44	0.44	0.43	0.43	0.43
1.5	0.48	0.47	0.47	0.46	0.46
1.6	0.51	0.50	0.50	0.49	0.49
1.7	0.55	0.54	0.53	0.53	0.52
1.8	0.59	0.57	0.56	0.56	0.56
1.9	0.62	0.61	0.60	0.59	0.59
2.0	0.66	0.64	0.63	0.63	0.62
2.1	0.70	0.68	0.67	0.66	0.65
2.2	0.74	0.72	0.70	0.69	0.69
2.3	0.78	0.75	0.74	0.73	0.72
2.4	0.82	0.79	0.77	0.76	0.75
2.5	0.86	0.83	0.81	0.80	0.79
2.6	0.90	0.86	0.84	0.83	0.82
2.7	0.94	0.90	0.88	0.87	0.86
2.8	0.99	0.94	0.92	0.90	0.89
2.9	1.03	0.98	0.95	0.94	0.92
3.0	1.07	1.02	0.99	0.97	0.96
3.1	1.12	1.06	1.03	1.01	0.99
3.2	1.17	1.10	1.07	1.05	1.03
3.3	1.22	1.15	1.11	1.08	1.07
3.4	1.27	1.19	1.15	1.12	1.10
3.5	1.32	1.23	1.19	1.16	1.14
3.6	1.37	1.28	1.23	1.19	1.17
3.7	1.43	1.32	1.27	1.23	1.21
3.8	1.49	1.37	1.31	1.27	1.25
3.9		1.41	1.35	1.31	1.28
4.0		1.46	1.39	1.35	1.32
4.2		1.56	1.48	1.43	1.40
4.4		1.66	1.57	1.51	1.48
4.6		1.77	1.66	1.60	1.55
4.8		1.89	1.75	1.68	1.63
5.0			1.85	1.77	1.72
5.2			1.95	1.86	1.80
5.4			2.06	1.95	1.88
5.6			2.17	2.05	1.97
5.8			2.29	2.14	2.06
6.0				2.24	2.15
6.2				2.35	2.24
6.4				2.46	2.34
6.6					2.44
6.8					2.54
7.0					2.64
7.2					2.75
7.4					

$$K_r = \frac{M_f \, 10^6}{bd^2} = \rho \phi_s f_y \left[1 - \frac{\rho \phi_s f_y}{1.7 \phi_c f'_c}\right]$$

$$\rho = \frac{A_s}{bd}$$



REINFORCED CONCRETE DESIGN TABLE

Source: CPCA Concrete Design Handbook

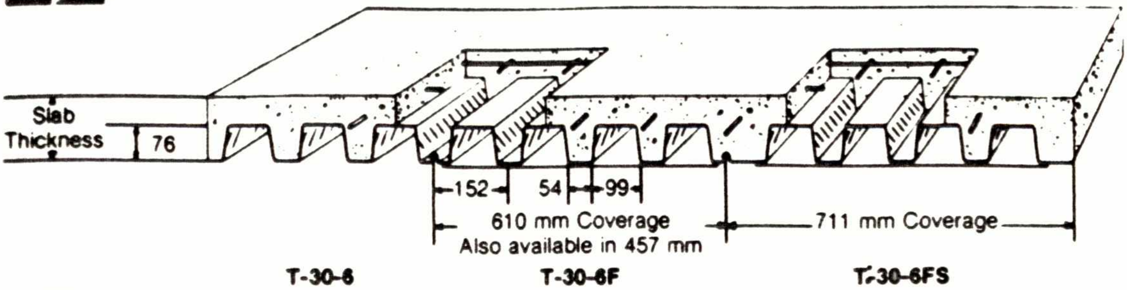
APPENDIX C

TECHNICAL DATA FOR METAL FORMED DECK

WESTEEL-ROSCO

Hi-Bond® Steel Floor

T-30-6 T-30-6F T-30-6FS



STEEL FLOOR — PHYSICAL PROPERTIES

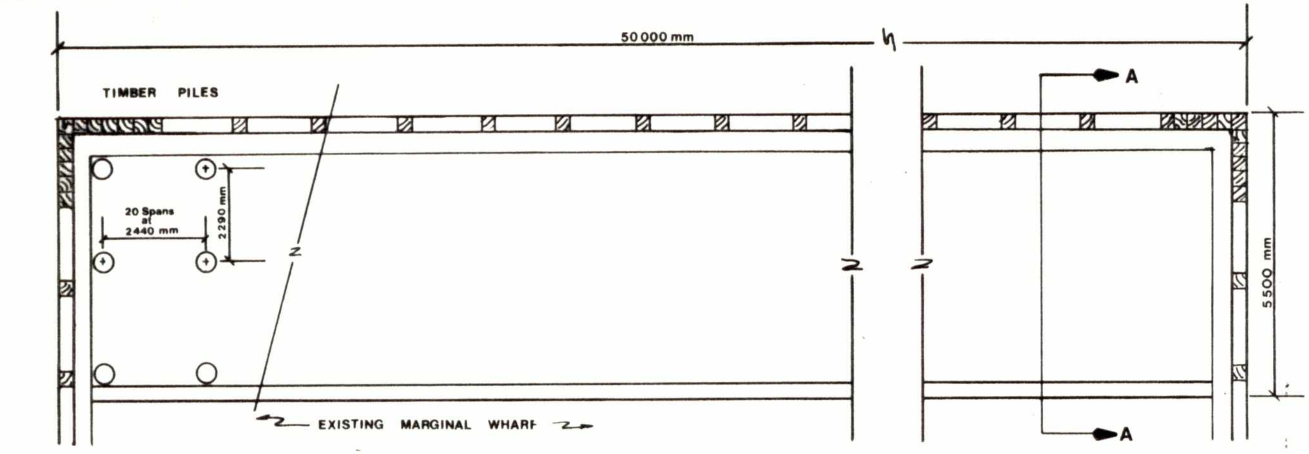
This table has been compiled in accordance with Canadian Standards Association Specifications S-136-1974. Properties for one metre width.

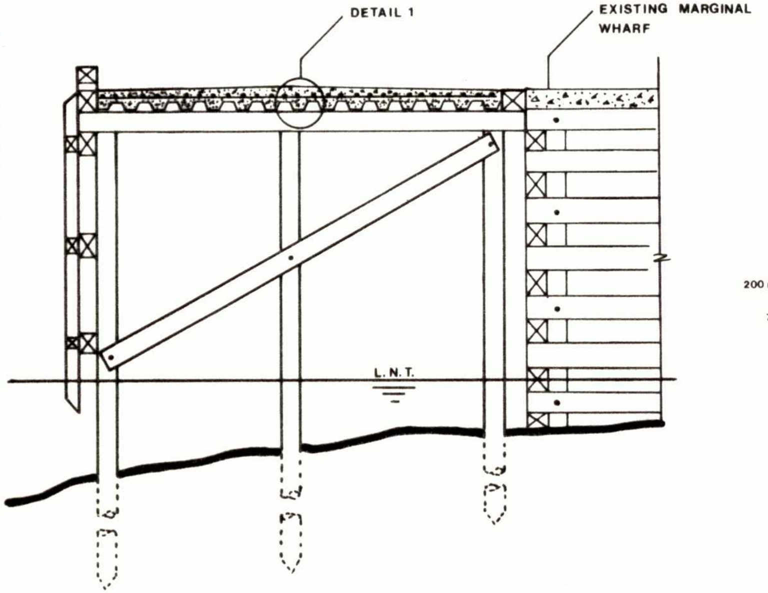
Base Steel Nominal Thickness mm	Base Steel Area mm²	Mass kg/m²	Effective Properties for Form Design: Section Modulus at Midspan mm³ x 10³ Sm	Section Modulus at Support mm³ x 10³ Ss	Effective Modulus of Inertia at Midspan mm⁴ x 10³ Ie	Properties for Slab Design: Section Modulus of Steel Floor To Bottom Fibre mm³ x 10³ Sb	Dimension from N.A. to Bottom Flange of Steel Profile mm Yb	Full Moment of Inertia mm⁴ x 10³ If	Allowable Support Reactions: Exterior kN	Interior kN
0.76	1431.6	12.01	25.76	27.64	1102.6	30.63	42.82	1311.6	8.1	16.6
0.91	1713.5	14.38	33.42	35.85	1414.2	36.54	42.93	1586.9	13.7	24.9
1.22	2295.5	19.18	47.23	48.64	2099.3	48.64	43.16	2099.3	27.7	46.2
1.52	2857.9	23.97	60.18	60.18	2610.6	60.18	43.38	2610.6	43.3	71.6

COMPOSITE SLAB — GENERAL DATA

			Regular Weight Concrete (N=9)				Light Weight Concrete (N=14)			
Slab Thickness	mm	t	141	151	161	166	141	151	161	166
Slab Weight	kPa	W_1	2.28	2.51	2.73	2.84	1.83	2.02	2.20	2.29
Max. Allow. Shear Bond	kN	V_A	13.3	14.4	15.6	16.2	13.3	14.4	15.6	16.2
Concrete Volume	m³/m²		.093	.106	.112	.119	.093	.106	.112	.119
Base Steel Nominal Thickness mm	0.76	Ic	8522	10324	12344	13437	7527	9126	10929	11907
		Sc	84	94	105	111	79	89	100	105
		St	1965	2241	2537	2693	2300	2619	2963	3144
	0.91	Ic	9699	11757	14069	15321	8495	10304	12346	13457
		Sc	98	110	123	130	92	104	116	123
		St	2093	2387	2702	2867	2443	2779	3142	3334
	1.22	Ic	11873	14404	17258	18808	10258	12442	14919	16270
		Sc	125	142	158	167	117	133	149	157
		St	2313	2634	2980	3163	2688	3050	3445	3653
	1.52	Ic	13720	16651	19966	21770	11735	14226	17062	18613
		Sc	150	170	191	201	140	158	178	188
		St	2486	2827	3197	3392	2882	3263	3679	3900

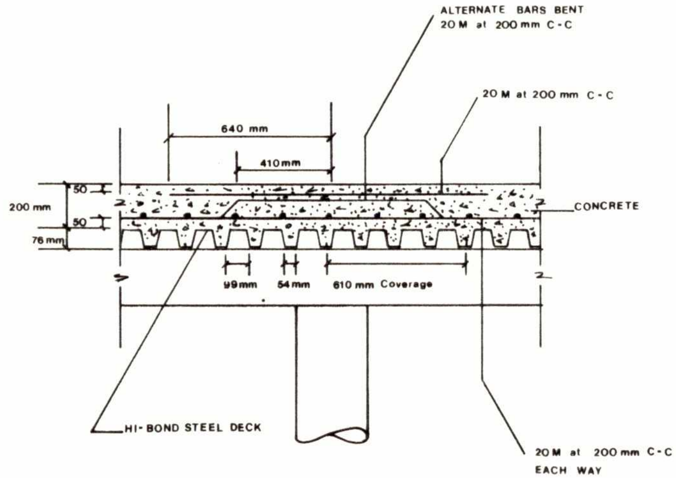
APPENDIX D
DESIGN PLAN AND DETAIL SPECIFICATIONS





SECTION A - A

N.T.S.



DETAIL 1

SCALE 1 : 20

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NOTES:

i) SPECIFIED YEILD STRENGTH OF REBAR IS 400 MPa AND 28 DAY COMPRESSIVE STRENGTH OF CONCRETE IS 30 MPa.

ii) METAL DECK HAS A SPECIFIED UNIT STRESS OF 142 MPa.

A detail no. | détail no.

B location drawing no. | sur dessin no.

C drawing no. | dessin no.

revisions | date

drawing title | titre du dessin

DESIGN PLAN AND DETAIL SPECIFICATIONS

designed by S. K. | conçu par

date Dec. 4 - 87

drawn by | dessiné par

date

reviewed by | examiné par

date

approved by | approuvé par

date

Tender | Soumission

Project Manager | Administrateur de projets

project number | no. du projet

drawing no. | dessin no.