

RESEARCH SERVICES

Ref No:	RS/RSC/S10244/1/87/D
Date:	19th October 1987
Classification:	CONFIDENTIAL

CONTRACT REPORT for

Steel Construction Institute

Indicative Fire Test on Composite Concrete/Steel Deck Floor System

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**INDICATIVE FIRE TEST ON COMPOSITE CONCRETE/STEEL
DECK FLOOR SYSTEM**

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SYNOPSIS

Staff of the British Steel Corporation, Swinden Laboratories, have successfully carried out a BS476:Part 20 fire test on an unloaded four-part concrete/steel deck floor system under contract to the Steel Construction Institute.

Temperature profiles through the various concrete floor/steel deck/beam assemblies were recorded for 120 mm deep lightweight and normal density concrete floors used in conjunction with two types of profiled steel decking - PMF CF46 and Super Holorib steel decks.

The test assembly was designed to give a 1½ h fire rating, and, after successfully achieving this, heating was continued to 105 min at which time the lightweight concrete on the PMF CF46 steel deck suddenly exploded causing the test to be terminated. This aspect will be further commented on by SCI in the final contract report.

KEY WORDS

- | | |
|--------------------|----------------|
| 3. Fire Resistance | 6. Metal Deck |
| 4. BS 476 | 7. Temperature |
| 5. Steel Beam | 8. Concrete |

19th October 1987

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INDICATIVE FIRE TEST ON COMPOSITE CONCRETE/STEEL DECK FLOOR SYSTEM

1. INTRODUCTION

The British Steel Corporation, Swinden Laboratories, was contracted by the Steel Construction Institute to carry out a BS476:Part 20 fire test on an unloaded composite concrete/steel deck floor system.

The object of the test was to obtain temperature profiles throughout the four floor assemblies which comprised two types of steel deck, PMF CF46 and Super Holorib, filled with either 120 mm of normal density or lightweight concrete after stud welding through the deck to two 406 x 178 mm x 60 kg/m universal steel beams which were protected with Mandolite P20 to give them 1½ h fire resistance.

This report gives details of the design and construction of the test assembly and also contains the temperatures measured during the heating period of the test.

2. FABRICATION OF TEST ASSEMBLY

2.1 Steel Beams

Two 4.8 m long 406 x 178 mm x 60 kg/m, BS4360:Grade 43A universal beams were modified to contain three 6 mm wide cuts which passed through their upper flanges and webs to a depth of 200 mm at the mid-span position and also 900 mm on each side of the centre (Fig. 1(a)). The purpose of the cuts was to provide thermal breaks in the steel beam. Lifting eyes were also welded onto the upper flange of each steel beam at 3 m centres (Fig. 1(b)).

2.2 Steel Decking

Two types of profiled steel decking were laid across the two steel beams at 1.5 m centres, such that both halves of the floor were symmetrically supported and the deck profiles were positioned at right angles to the steel beams (Fig. 1(c)). One of the steel decks comprised Super Holorib which is a profiled galvanised sheet steel decking of 1.2 mm nominal thickness which was 610 mm wide by 3200 mm long as supplied by Richard Lees Ltd. The other steel deck type comprised a trapezoidal profiled galvanised sheet steel decking supplied by Precision Metal Forming Ltd. and referenced CF46 and was of 1.2 mm nominal thickness supplied in sheets 900 mm wide by 3200 mm long.

The steel decking was fixed together with steel pop-rivets at 600 mm centres and the joint between the two types cut to suit and fixed together with pop-rivets. The steel decks were attached to the steel beams with headed shear stud connectors Type HSC19100 of size 19 mm diameter by 100 mm long which were stud welded through the deck into alternate troughs (Fig. 2) by Studwelders Ltd.

3. INSTRUMENTATION

3.1 Concrete

Six areas were selected within each of the four segments at the positions shown in Fig. 3 and within these areas 118 thermocouples were sited at different depths and positions relative to the steel deck profile as

shown in Fig. 4. The thermocouples were welded, bare wire chromel/alumel glass fibre insulated and sheathed which were assembled into rigid grid formations to enable accurate siting at their respective positions. Each frame of the grid was first glued into position with quick setting Araldite, the thermocouple depths were then set and the concrete carefully packed around them (Fig. 5).

The unexposed surface temperatures were monitored using the recommended standard technique which comprised of a chromel/alumel bare wire thermocouple brazed to a copper disc inserted between an insulating pad and bonded to the surface of the concrete.

Eight thermocouples were attached to the steel decks, two in each segment at position A, at the concrete interface. These thermocouples were spot welded to the deck surface after removing the galvanised layer and were also held in position with a small self tapping screw (Fig. 6(a)).

Four thermocouples were embedded into two shear stud connectors in segments containing normal density concrete (CF46 deck) and lightweight concrete (Holorib deck) at the head and the mid-height shank positions (Fig. 6(b)).

3.2 Reinforcement Mesh

Four additional pieces of reinforcement mesh, fabricated from 5 mm diameter rods, were included in segments of lightweight (Holorib) and normal density concrete (CF46), two in each. The dimensions, locations of the grids and thermocouple positions on the mesh are shown in Figs. 7 and 8.

3.3 Steel Beams

A total of 32 chromel/alumel Type K mineral insulated, inconel sheathed thermocouples were attached to the steel beams in areas under each of the four concrete floor segments. Each segment contained one thermocouple on the lower flange, three on the web and four on the upper flange, two of which were in areas where the voids in the steel deck profiles were not filled with fire protection materials. All the thermocouple positions are given in Fig. 9.

3.4 Furnace Gas

Five thermocouples were used to monitor the furnace gas temperature, three (1-3) of which were positioned between the beams at 1 m intervals along the centreline of the assembly, level with the lower flange and one on either side (4-5) between the furnace wall and lower flange on a central axis 230 mm from the lower flange of the beam.

4. CONCRETE COVERING

A schematic layout of the concrete/steel decking test arrangement is given in Fig. 3. Both the steel decks were shuttered to form four equal segments to be filled with two different types of concrete. Bulk mixed normal density BS8110:Grade 25 concrete was cast into two diagonally opposite segments while lightweight Lytag aggregate concrete was mixed (4 $\frac{1}{2}$ Lytag:1 Portland cement) on site and cast into the remaining segments.

Each quarter of the floor area was reinforced with a steel mesh BS4483 reference A142, positioned at a distance of 25 mm from the top surface. The concrete was thoroughly compacted by a 25 mm poker type vibrator which was continuously used during casting until the expulsion of air bubbles had practically ceased (Figs. 10 and 11). The concrete depths of 120 mm were achieved by scraping and trowelling of the surplus concrete (Fig. 10(c)).

The normal density concrete was cast on the 17th March 1987 and the lightweight concrete was cast the following day which allowed the internal shuttering to be removed between the segments and a layer of ceramic fibre fitted (Fig. 11(a)) to thermally isolate the different segments.

Four standard 150 mm test cubes were sampled during the casting of each concrete type. Two cubes from each batch were used for compressive strength assessment, after 7 days and on the day of the test, the results are given in Table 1. The remaining two had five faces masked with a chlorinated rubber paint and weighed every two weeks to monitor curing.

The concrete floor assembly was left to cure approximately 18 weeks before testing. During the first 6 weeks it was outside of the laboratory but covered by a polythene tent, having adequate ventilation. The assembly was then moved indoors for the remaining 12 weeks, for conditioning within the testing area. Moisture contents were measured using the Concrete Master meter which involves inserting two probes into 6 mm diameter holes drilled to the depth required at approximately 25 mm centres. Measurements made on the day of the test are presented in Table 2 and indicate that the average moisture content of the normal density concrete was 4.8% and 5.1% for the lightweight.

After oven drying at 105°C, the test cube samples of the normal density concrete were found to exhibit a moisture content of 3.4% while the lightweight concrete contained 6.2%.

5. PROTECTION OF STEEL BEAMS

Prior to spraying the cuts in the steel beams were packed tightly with ceramic fibre blanket (Fig. 12) and the voids between the beam and steel decks were packed with mineral fibre (Rockwool), following normal site practice. The 406 x 178 mm x 60 kg/m universal beams were sprayed with Mandolite P20 during the week commencing 18th May 1987 by Mandovals Ltd. to provide 1½ h fire resistance (Fig. 13(a)). The coating thicknesses of the protection are shown in the following table.

	Lower Flange, mm			Web, mm		
	Mean	Min.	Max.	Mean	Min.	Max.
Beam 1	29.8	22	34	29.8	24	35
Beam 2	30.5	28	32	27.5	22	33

Prior to testing the two designated voids in each segment between the deck and beam had their protection cut out and the infill removed to expose the upper flange (Figs. 13(b) and (c)) while leaving a 10 mm thick lip of protection above the flange surface.

A small area of protection adjacent to the furnace support on one beam was damaged while positioning it in the furnace but this was repaired by bonding a piece of ceramic fibre blanket to the area.

Oven drying the spray sample trays revealed that the Mandolite P20 coating on the day of the test had a moisture content of 10% and a density of 376 kg/m³.

6. RESULTS OF FIRE TEST

The standard fire resistance test was carried out at the Warrington Fire Research Centre on the 22nd July 1987 where the test assembly was subjected to the heating conditions required in BS476:Part 20.

The outputs from all the thermocouples were recorded every 60 s by the BSC Compulog computer controlled data acquisition system and the data stored on floppy disks.

The test was originally designed for a period of $1\frac{1}{2}$ h fire resistance. However, it was agreed with Mr. G.H. Newman of the Steel Construction Institute that, provided the sample remained sound after 90 min, heating should continue to 120 min.

The following general observations were made during the test:-

Min	
15	Floor starting to hog longitudinally
20	Slight amount of moisture visible on the unexposed face of the lightweight slabs
27	Floor sagging towards the central vertical joint by about 20 mm
28	Transverse hairline cracks appearing on both normal density and lightweight segments at $\frac{1}{3}$ and $\frac{2}{3}$ length positions (see Fig. 14(a))
29	Slight amount of moisture on surface of normal density concrete
37	Much more moisture on lightweight than normal density slabs (see Fig. 14(b))
54	Piece of ceramic fibre blown out of longitudinal joint over CF46 deck which distorted the deck slightly (see Fig. 15)
80	Moisture almost dried up on the surface of both types of concrete slabs
90	The ends of the individual concrete slabs curving upwards due to the expansion of the soffit
103	the CF46 decking separating from the lightweight concrete adjacent to the longitudinal perimeter wall
105	The lightweight concrete on the CF46 deck suddenly exploded in above area (Fig. 16) which resulted in large pieces of concrete being thrown around the laboratory. Test was discontinued. (Further commentary on this aspect will be made by SCI in the final contract report.)

The normal density concrete appeared to be still in close contact with the CF46 deck after the test as was also the case with both types of concrete on the Holorib deck.

The results of the heating rates obtained from all the thermocouple outputs are presented in Tables 3 to 21.

7. CONCLUSIONS

A BS476:Part 20 fire test on an unloaded, four part, concrete/steel deck floor assembly has been successfully carried out by staff of BSC, Swinden Laboratories on behalf of the Steel Construction Institute.

The outputs from all the thermocouples were satisfactorily recorded throughout the test providing temperature profiles for 120 mm deep floors made up of normal density and lightweight concrete with both Super Holorib and PMF CF46 steel floor decks.

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TABLE 1
COMPRESSIVE STRENGTH RESULTS

Concrete Type	Age Days	Density kg/m ³	Compressive Strength MN/m ²
Normal Density	7	2340	28.5
Normal Density	126	2360	45.0
Lightweight	7	1960	38.0
Lightweight	126	1970	55.0

TABLE 2
MOISTURE CONTENTS ON DAY OF TEST

Concrete Type	Moisture Content, % and Depths Below Surface		
	30 mm	60 mm	85 mm
Normal Density	3.7	4.7	6.1
Lightweight	3.8	5.2	6.5

TABLE 3
FURNACE GAS TEMPERATURES

TIME (min)	TEMPERATURE (C) FURNACE GAS				
	1	2	3	4	5
0.0	23	23	23	22	23
1.0	566	619	575	499	531
2.0	378	413	392	359	367
3.0	422	466	441	403	419
4.0	595	652	611	544	565
5.0	570	621	592	524	549
6.0	565	619	593	543	557
7.0	574	628	599	545	561
8.0	580	629	606	552	563
9.0	602	653	619	547	586
10.0	611	665	628	557	573
11.0	636	694	655	575	599
12.0	645	700	658	575	601
13.0	671	724	684	588	607
14.0	678	730	693	590	608
15.0	695	749	711	609	623
16.0	721	763	729	633	626
17.0	732	781	743	636	638
18.0	753	797	767	661	655
19.0	764	813	776	687	679
20.0	765	812	778	691	678
21.0	786	829	795	709	683
22.0	782	836	795	713	697
23.0	797	841	797	727	715
24.0	787	843	806	718	699
25.0	793	841	809	717	698
26.0	798	845	810	730	714
27.0	798	853	820	727	712
28.0	802	864	820	737	734
29.0	806	860	825	737	734
30.0	809	865	823	750	733
31.0	815	875	831	760	738
32.0	827	878	839	773	745
33.0	827	886	850	784	752
34.0	838	890	843	771	747
35.0	835	889	852	766	755
36.0	837	885	863	767	749
37.0	841	897	862	792	763
38.0	842	899	860	787	755
39.0	850	899	868	787	766
40.0	850	903	864	801	767
41.0	857	911	870	808	780
42.0	855	915	867	795	784
43.0	866	912	876	799	796
44.0	864	903	875	805	777
45.0	872	914	881	800	786
46.0	875	920	887	811	799
47.0	875	926	886	817	802
48.0	887	922	888	818	806
49.0	889	923	881	824	806
50.0	894	925	893	829	810
51.0	891	927	889	826	818
52.0	891	937	896	832	815
53.0	896	938	894	843	822
54.0	900	941	909	841	825
55.0	897	936	904	839	835
56.0	910	941	908	849	835
57.0	908	950	911	853	838
58.0	910	941	914	849	825
59.0	913	949	915	856	841
60.0	914	946	920	855	836
62.0	917	956	930	865	843
64.0	926	963	927	876	861
66.0	934	966	933	872	864
68.0	943	965	939	888	868
70.0	941	969	953	890	868
72.0	947	975	958	890	877
74.0	952	979	959	897	881
76.0	957	982	961	894	893
78.0	959	992	968	911	890
80.0	962	991	975	914	894
82.0	965	992	976	924	892
84.0	974	1001	978	927	905
86.0	975	997	985	933	905
88.0	976	1008	986	934	911
90.0	983	1012	991	938	919
92.0	987	1017	993	940	927
94.0	994	1020	995	946	932
96.0	998	1019	995	946	937
98.0	1001	1026	1001	952	939
100.0	1003	1032	1006	960	943
102.0	1007	1031	1007	963	947
104.0	1012	1036	1012	966	953
105.0	1015	1037	1015	966	957

TABLE 5
HEATING RATES OF GROUP B IN NW CONCRETE WITH PMF DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION B1					TEMPERATURE (C) CONCRETE POSITION B2			
	2	6	8	12	14	2	6	8	12
0.0	22	22	22	22	22	22	23	22	23
2.0	22	23	22	24	21	22	35	22	26
4.0	22	27	22	28	21	24	45	24	32
6.0	23	32	23	33	22	27	72	27	43
8.0	24	38	23	39	22	31	96	30	57
10.0	26	44	25	45	23	37	103	35	69
12.0	27	50	27	52	24	46	108	42	81
14.0	30	57	29	59	25	56	111	49	93
16.0	32	63	31	66	27	64	113	59	106
18.0	35	70	33	73	29	69	120	66	108
20.0	40	78	37	81	31	71	133	72	110
22.0	44	94	42	87	34	73	147	77	113
24.0	47	101	47	95	37	76	163	83	116
26.0	51	102	52	99	40	80	179	92	121
28.0	54	102	56	102	44	84	196	95	129
30.0	57	102	59	103	48	88	214	97	138
32.0	60	102	62	103	52	95	232	100	149
34.0	63	103	66	104	58	97	251	102	162
36.0	66	103	70	107	65	102	269	104	175
38.0	68	103	73	112	73	103	285	104	187
40.0	71	105	76	118	80	103	300	104	200
41.0	72	107	77	120	82	103	308	104	206
42.0	74	110	79	123	83	103	315	104	213
43.0	75	112	80	127	84	103	322	104	218
44.0	76	115	82	130	85	103	329	104	225
45.0	77	119	83	133	87	103	336	104	231
46.0	79	122	84	137	87	104	343	105	237
47.0	80	126	86	140	89	105	349	105	243
48.0	81	130	86	144	90	107	356	106	249
49.0	82	134	87	148	91	109	362	106	254
50.0	83	138	88	152	92	112	368	108	260
51.0	84	142	89	155	93	115	375	110	266
52.0	85	146	90	159	94	118	381	113	271
53.0	86	150	91	163	94	121	387	116	277
54.0	87	154	92	166	95	123	393	119	282
55.0	88	157	93	170	96	126	399	121	287
56.0	89	161	93	173	96	129	405	125	292
57.0	90	164	94	177	97	132	411	128	297
58.0	90	168	95	180	97	135	417	131	302
59.0	91	172	96	184	98	138	423	134	308
60.0	92	175	96	188	98	140	428	137	312
61.0	93	188	97	192	98	143	434	140	317
62.0	93	182	98	196	99	146	440	143	322
63.0	94	186	99	200	98	148	445	146	326
64.0	95	189	100	203	99	150	450	149	331
65.0	96	193	100	207	99	152	455	152	336
66.0	97	196	100	211	99	155	461	154	340
67.0	98	200	100	215	100	157	466	158	345
68.0	98	203	100	218	100	159	471	161	350
69.0	99	207	100	222	100	161	477	163	355
70.0	100	210	100	226	100	163	482	166	360
71.0	101	214	100	230	100	165	486	169	365
72.0	101	217	100	233	100	167	492	172	369
73.0	101	221	100	237	101	170	497	175	374
74.0	102	225	100	241	101	172	501	178	379
75.0	103	229	101	245	102	173	506	180	384
76.0	104	232	100	249	102	175	511	183	388
77.0	105	236	100	253	102	178	516	186	393
78.0	106	240	101	257	102	179	520	189	398
79.0	108	243	101	262	102	181	525	192	402
80.0	109	247	102	266	102	183	529	194	407
81.0	110	251	103	270	102	185	534	197	411
82.0	112	255	104	274	102	187	538	200	416
83.0	113	258	105	279	103	189	542	202	420
84.0	114	262	106	283	103	191	546	205	424
85.0	116	266	107	287	103	193	550	208	428
86.0	117	270	108	291	104	195	554	211	433
87.0	118	273	110	295	105	197	558	213	437
88.0	120	277	111	299	106	199	562	215	441
89.0	121	281	112	303	107	201	566	218	445
90.0	122	284	113	307	109	203	571	221	449
91.0	124	288	115	311	110	205	575	223	453
92.0	125	292	116	316	111	207	579	226	457
93.0	126	295	117	320	113	209	583	228	461
94.0	128	299	119	323	114	211	587	231	465
95.0	130	303	120	327	115	213	591	233	469
96.0	131	306	121	331	117	215	595	236	472
97.0	132	309	123	335	118	218	599	238	476
98.0	134	313	124	339	120	220	603	241	480
99.0	135	317	126	343	121	223	607	243	484
100.0	136	320	128	347	123	224	610	246	487
101.0	138	324	129	351	125	227	615	248	491
102.0	139	327	130	354	126	229	618	250	494
103.0	141	331	132	358	128	231	622	252	498
104.0	142	334	133	362	129	233	626	255	501
105.0	144	338	135	365	131	236	630	257	505

TABLE 6
HEATING RATES IN GROUP C IN NW CONCRETE WITH PMF DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION C1				TEMPERATURE (C) CONCRETE POSITION C2		
	4	12	14	16	2	12	14
0.0	23	22	22	23	22	23	22
2.0	23	23	22	23	22	26	22
4.0	22	26	22	22	25	33	23
6.0	23	31	22	22	28	44	26
8.0	23	37	22	22	34	56	30
10.0	24	44	23	23	40	68	36
12.0	25	55	24	23	51	81	43
14.0	27	74	26	23	68	93	52
16.0	28	87	28	23	72	102	63
18.0	31	96	32	25	76	107	74
20.0	34	96	37	26	80	108	83
22.0	37	96	42	28	86	111	90
24.0	43	98	46	31	92	115	96
26.0	51	99	50	33	97	123	100
28.0	61	100	53	37	102	134	102
30.0	65	101	57	39	103	149	102
32.0	62	102	60	42	103	163	103
34.0	60	103	64	45	103	177	104
36.0	61	105	66	48	104	191	104
38.0	60	109	69	51	104	205	104
40.0	61	115	72	53	107	220	105
41.0	62	118	73	54	111	227	106
42.0	62	123	74	56	115	234	108
43.0	62	127	75	57	120	241	110
44.0	62	131	76	58	125	249	114
45.0	62	135	77	59	130	256	118
46.0	62	140	77	60	134	262	122
47.0	63	146	78	61	137	269	126
48.0	63	151	79	62	141	276	131
49.0	64	157	80	63	144	282	135
50.0	64	163	81	64	147	289	140
51.0	65	169	82	65	150	295	146
52.0	66	174	83	66	153	301	151
53.0	66	180	84	67	156	307	156
54.0	67	186	84	68	158	313	162
55.0	68	192	85	68	161	318	167
56.0	71	197	85	72	164	324	173
57.0	73	203	85	73	167	330	179
58.0	75	209	85	74	170	335	185
59.0	78	216	86	75	173	341	191
60.0	77	222	86	75	175	346	197
61.0	79	228	87	76	177	352	204
62.0	79	233	87	77	180	357	210
63.0	80	239	88	77	183	363	216
64.0	81	244	88	78	185	369	222
65.0	81	250	89	78	188	374	228
66.0	82	255	90	79	191	379	233
67.0	83	261	90	79	194	385	239
68.0	85	266	91	80	196	391	244
69.0	86	272	91	81	199	396	250
70.0	87	277	92	81	202	401	255
71.0	89	283	93	82	205	406	260
72.0	89	290	93	82	208	411	265
73.0	90	296	94	83	211	416	270
74.0	91	302	94	83	213	421	274
75.0	91	307	94	84	216	425	279
76.0	93	312	95	85	219	430	284
77.0	94	317	96	86	222	436	288
78.0	96	322	97	86	225	440	293
79.0	97	327	100	87	228	445	297
80.0	98	332	102	87	232	449	302
81.0	99	337	104	88	234	454	306
82.0	101	342	106	88	237	459	310
83.0	103	347	108	89	240	463	314
84.0	104	351	110	90	244	468	318
85.0	105	356	112	90	248	472	323
86.0	106	360	114	91	250	476	326
87.0	108	365	116	91	254	480	330
88.0	107	370	118	92	256	484	334
89.0	110	374	120	92	261	488	338
90.0	111	378	122	93	264	492	342
91.0	113	382	124	94	268	496	346
92.0	113	387	126	94	270	500	350
93.0	114	391	127	94	274	503	353
94.0	115	395	129	95	277	507	357
95.0	116	398	131	96	281	511	360
96.0	117	402	132	97	285	514	364
97.0	119	405	134	97	288	518	367
98.0	120	408	136	98	292	522	371
99.0	121	410	137	99	295	526	374
100.0	123	411	138	100	298	529	378
101.0	124	414	140	100	301	533	381
102.0	125	417	141	101	305	536	384
103.0	127	419	142	102	308	540	388
104.0	128	422	143	103	312	543	391
105.0	130	426	144	104	315	547	394

TABLE 8
HEATING RATES OF GROUP B IN LW CONCRETE WITH PMF DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION B1					TEMPERATURE (C) CONCRETE POSITION B2			
	2	6	8	12	14	2	6	8	12
0.0	21	21	22	20	20	22	22	22	22
2.0	21	24	22	20	20	22	33	22	20
4.0	21	29	22	21	20	22	43	22	21
6.0	23	37	22	23	20	24	60	22	23
8.0	25	46	23	26	20	27	74	23	27
10.0	28	55	25	30	20	31	87	24	33
12.0	31	63	26	34	20	36	98	26	37
14.0	35	69	28	39	21	41	110	29	43
16.0	38	75	30	43	21	46	115	33	48
18.0	42	80	32	48	21	53	131	37	56
20.0	46	86	35	52	22	60	145	40	62
22.0	50	92	37	57	22	69	157	44	93
24.0	54	97	40	62	23	77	168	49	102
26.0	59	101	43	67	24	83	179	54	102
28.0	63	105	46	73	25	89	190	59	103
30.0	67	109	50	77	26	93	203	65	103
32.0	71	113	52	83	26	98	219	70	104
34.0	76	119	56	88	28	100	236	75	107
36.0	80	124	59	93	29	102	255	79	111
38.0	85	131	62	98	31	104	275	83	115
40.0	89	137	65	103	32	105	293	86	118
41.0	91	141	67	106	33	107	302	88	119
42.0	93	145	69	109	34	107	311	90	121
43.0	95	149	70	112	35	108	319	92	122
44.0	97	153	72	114	36	109	326	93	124
45.0	99	157	73	116	37	109	334	94	125
46.0	101	162	75	118	38	110	341	95	126
47.0	103	167	77	121	39	112	349	97	128
48.0	104	171	78	123	40	112	355	98	129
49.0	106	177	80	125	41	113	362	99	130
50.0	107	182	81	127	42	114	369	100	131
51.0	109	188	83	129	43	115	376	101	132
52.0	110	193	84	131	44	116	382	102	133
53.0	112	199	86	133	45	117	388	103	135
54.0	114	205	88	135	46	119	395	104	136
55.0	115	211	89	137	47	120	401	105	137
56.0	117	217	91	139	49	122	407	106	137
57.0	118	223	93	141	50	123	413	107	138
58.0	120	229	94	143	51	125	419	108	141
59.0	121	234	96	145	52	127	425	108	144
60.0	122	240	97	147	53	129	431	109	149
61.0	123	245	99	149	55	130	436	109	152
62.0	124	250	100	150	56	133	442	111	156
63.0	126	256	101	153	57	134	448	111	159
64.0	127	261	103	154	58	137	453	112	162
65.0	128	266	104	156	60	139	458	112	165
66.0	129	272	105	158	61	142	464	113	168
67.0	131	277	107	160	62	145	469	114	171
68.0	132	282	108	161	63	147	474	115	174
69.0	133	287	109	163	65	150	479	115	177
70.0	135	292	111	165	66	153	484	116	180
71.0	137	296	112	166	67	156	489	117	183
72.0	138	301	113	168	69	159	494	117	186
73.0	140	305	114	169	70	162	499	118	189
74.0	141	310	116	171	71	165	504	119	192
75.0	143	314	117	172	72	168	509	119	196
76.0	144	318	118	174	74	171	513	120	199
77.0	146	323	119	175	75	173	518	120	202
78.0	147	327	121	176	76	176	522	121	205
79.0	149	332	122	178	78	179	526	121	208
80.0	150	336	123	179	79	182	531	122	212
81.0	152	341	125	180	80	185	535	122	215
82.0	153	345	126	182	81	188	540	123	219
83.0	155	350	127	183	82	191	544	123	222
84.0	156	354	128	185	83	194	548	123	225
85.0	158	358	129	187	85	196	552	124	229
86.0	160	363	131	189	86	200	557	125	233
87.0	161	367	132	190	87	203	561	126	236
88.0	163	371	133	192	88	206	566	127	240
89.0	164	376	134	194	90	209	570	127	244
90.0	166	380	136	196	91	211	574	128	247
91.0	167	384	137	198	93	214	579	128	251
92.0	169	388	138	200	94	217	583	129	254
93.0	171	392	139	202	95	220	588	130	258
94.0	172	396	140	204	96	223	592	130	261
95.0	174	400	141	206	98	226	596	131	265
96.0	176	404	142	209	99	228	601	132	269
97.0	178	408	143	212	100	231	605	133	273
98.0	180	412	144	216	102	234	609	134	277
99.0	181	416	145	220	103	236	613	135	281
100.0	184	420	146	224	105	239	617	136	284
101.0	186	423	147	228	106	242	621	137	288
102.0	188	427	149	232	107	245	625	137	292
103.0	190	431	150	236	108	248	629	139	296
104.0	193	435	151	240	109	250	633	140	300
105.0	196	439	152	245	110	253	637	141	304

TABLE 9
HEATING RATES OF GROUP C IN LW CONCRETE WITH PMF DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION C1				TEMPERATURE (C) CONCRETE POSITION C2		
	4	12	14	16	2	12	14
0.0	22	21	21	21	22	22	22
2.0	22	21	21	21	22	22	22
4.0	21	21	21	21	24	22	22
6.0	22	22	21	21	26	22	22
8.0	22	24	21	21	30	22	22
10.0	22	27	21	21	35	23	22
12.0	22	30	21	22	41	24	22
14.0	22	33	21	22	52	25	22
16.0	22	37	21	22	66	27	22
18.0	22	41	21	22	75	30	23
20.0	23	44	22	22	82	33	23
22.0	23	49	22	22	88	37	24
24.0	24	54	23	23	93	41	26
26.0	24	59	23	23	98	45	27
28.0	25	65	24	23	104	49	30
30.0	26	70	24	23	109	54	33
32.0	26	77	25	23	116	60	38
34.0	27	84	26	23	121	65	43
36.0	28	92	27	23	126	70	47
38.0	29	100	28	24	132	76	51
40.0	30	109	30	24	135	81	55
41.0	31	114	31	24	137	83	57
42.0	32	118	32	25	140	86	58
43.0	33	122	33	25	142	89	60
44.0	33	126	34	26	143	91	61
45.0	34	130	35	26	144	93	63
46.0	35	134	36	27	146	96	64
47.0	36	138	38	27	150	99	66
48.0	37	140	39	27	152	99	67
49.0	37	143	40	28	153	103	69
50.0	38	145	41	28	154	105	70
51.0	39	148	43	28	157	107	71
52.0	40	150	44	28	159	108	72
53.0	40	152	46	29	161	111	74
54.0	41	154	47	29	163	112	75
55.0	41	155	49	30	165	115	77
56.0	41	157	51	30	167	117	78
57.0	42	159	52	31	169	118	79
58.0	41	161	54	31	170	121	81
59.0	42	162	56	32	172	122	82
60.0	42	164	57	32	174	125	83
61.0	43	165	59	33	176	125	84
62.0	43	167	61	33	180	128	86
63.0	44	168	62	34	182	130	87
64.0	44	170	63	34	185	130	87
65.0	45	172	65	35	188	132	88
66.0	46	173	67	35	191	135	90
67.0	46	175	68	36	194	135	91
68.0	46	176	70	37	197	137	92
69.0	47	177	71	37	200	138	93
70.0	47	179	73	38	203	141	95
71.0	48	180	74	39	205	141	95
72.0	49	181	76	39	208	144	97
73.0	49	183	77	40	211	145	98
74.0	50	184	78	41	214	147	99
75.0	50	184	79	41	217	149	100
76.0	50	186	81	42	221	150	101
77.0	51	187	82	42	224	152	101
78.0	51	188	83	43	227	153	102
79.0	52	190	84	43	230	154	104
80.0	53	191	86	44	232	156	105
81.0	54	192	87	44	235	157	105
82.0	53	193	89	45	238	159	107
83.0	53	195	90	45	240	160	107
84.0	54	195	91	46	242	162	108
85.0	54	198	93	46	244	163	109
86.0	55	199	94	47	247	164	110
87.0	55	201	96	48	249	165	111
88.0	55	203	97	49	252	167	113
89.0	56	207	98	49	254	168	113
90.0	57	210	100	49	256	170	113
91.0	57	214	101	50	258	170	115
92.0	58	218	103	50	260	172	115
93.0	59	221	104	51	262	173	116
94.0	59	225	105	52	264	174	117
95.0	60	230	107	52	266	175	117
96.0	60	234	108	52	268	176	118
97.0	61	238	109	53	270	177	119
98.0	61	243	110	53	272	178	119
99.0	62	248	110	54	275	179	121
100.0	62	253	111	55	278	181	122
101.0	63	258	112	55	280	182	123
102.0	63	262	113	56	283	182	124
103.0	64	267	113	56	285	183	125
104.0	64	271	113	57	288	184	125
105.0	65	275	114	57	291	185	126

TABLE 10
HEATING RATES OF GROUP A IN NW CONCRETE WITH BOLORIB DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION A1								TEMPERATURE (C) CONCRETE POSITION A2							
	2	3	8	10	11	12	14		2	3	8	10	11	12	14	
0.0	22	22	22	23	22	22	22		23	22	23	23	21	22	22	
2.0	22	22	22	22	22	22	22		23	22	22	23	21	22	22	
4.0	22	22	22	22	22	22	22		23	22	22	22	22	22	22	
6.0	22	22	22	22	23	22	22		23	22	22	23	23	22	22	
8.0	22	22	22	22	25	22	22		24	22	23	23	25	22	22	
10.0	23	22	22	22	27	23	22		24	23	23	22	27	23	22	
12.0	23	22	22	23	30	24	22		25	23	23	23	30	24	22	
14.0	24	23	23	23	34	25	22		26	24	24	23	34	26	23	
16.0	25	23	23	23	37	27	23		27	24	25	23	38	27	23	
18.0	26	24	23	24	42	28	23		28	25	25	23	41	30	24	
20.0	28	25	25	25	47	31	24		30	26	27	24	48	33	25	
22.0	30	26	26	25	52	33	25		32	27	28	24	53	38	26	
24.0	32	27	27	26	58	36	26		34	29	30	25	61	43	27	
26.0	35	29	29	27	63	40	27		37	30	33	26	68	48	29	
28.0	39	30	32	28	69	44	29		39	32	35	27	73	53	31	
30.0	43	33	37	30	74	49	30		42	34	37	28	78	58	33	
32.0	47	35	40	31	79	53	33		44	36	40	29	83	63	35	
34.0	50	37	44	33	84	58	35		47	38	42	30	89	67	38	
36.0	53	39	46	35	88	62	38		49	40	44	32	95	70	40	
38.0	55	42	49	36	92	66	40		52	42	47	33	93	73	42	
40.0	58	44	52	38	96	70	43		55	45	49	35	94	76	45	
41.0	59	45	53	39	98	72	45		57	46	50	35	94	77	46	
42.0	61	46	55	40	100	74	46		59	47	51	36	96	78	47	
43.0	63	47	58	41	102	76	47		60	48	52	37	97	79	48	
44.0	64	49	60	42	103	78	49		62	50	53	38	99	80	50	
45.0	66	50	62	44	106	80	50		64	51	55	39	99	82	51	
46.0	68	52	64	45	108	82	52		66	53	56	40	99	83	52	
47.0	69	53	66	47	110	85	53		69	54	57	40	101	83	53	
48.0	71	55	68	48	112	87	55		71	56	58	41	104	84	54	
49.0	73	56	70	49	115	90	56		73	58	60	42	107	86	55	
50.0	74	57	73	50	117	92	58		75	60	61	43	110	87	57	
51.0	76	59	75	50	120	94	59		77	62	62	44	112	88	58	
52.0	78	61	77	51	123	97	61		78	63	64	45	113	89	59	
53.0	80	63	79	52	126	100	63		80	65	65	46	116	91	60	
54.0	81	65	81	53	129	102	65		81	67	66	47	118	92	61	
55.0	83	67	82	53	132	104	66		83	68	68	48	120	93	62	
56.0	84	70	84	53	135	106	68		84	69	69	49	123	94	63	
57.0	86	72	86	54	138	107	69		85	71	71	50	126	95	65	
58.0	88	74	87	54	141	107	72		86	72	72	51	128	96	66	
59.0	89	76	88	55	145	107	74		87	73	74	52	131	98	67	
60.0	91	78	90	56	148	107	76		88	74	75	53	133	99	69	
61.0	92	80	91	57	151	107	78		89	76	76	54	137	100	70	
62.0	94	81	92	58	155	107	80		90	77	77	55	139	101	72	
63.0	95	83	93	59	158	107	83		90	78	79	56	142	102	73	
64.0	96	85	94	60	162	107	87		91	78	80	57	145	103	75	
65.0	98	86	95	61	165	107	90		92	79	82	58	148	103	77	
66.0	99	88	96	63	168	108	92		92	80	83	59	151	103	78	
67.0	100	90	97	64	172	107	93		93	81	84	60	154	103	80	
68.0	102	92	98	63	176	107	95		93	81	85	60	157	103	81	
69.0	103	94	99	35	180	107	96		94	82	86	61	160	103	83	
70.0	104	96	99	35	183	107	97		95	83	87	62	163	104	85	
71.0	104	98	100	38	187	107	97		95	84	88	63	166	104	86	
72.0	104	99	100	40	191	107	98		96	84	88	63	169	104	88	
73.0	105	100	100	39	194	107	99		96	85	90	64	172	104	89	
74.0	105	100	100	40	198	107	100		97	86	90	65	175	104	90	
75.0	105	100	100	41	202	107	100		97	86	91	65	177	104	91	
76.0	105	101	100	40	205	106	100		98	87	92	66	180	104	92	
77.0	105	101	100	41	209	107	100		99	87	93	67	184	105	93	
78.0	105	101	100	42	213	107	101		99	88	94	67	187	105	94	
79.0	105	101	100	42	216	108	102		100	89	95	68	190	105	95	
80.0	105	101	100	44	220	108	102		101	89	96	69	193	105	96	
81.0	105	101	100	44	224	109	102		102	90	97	70	196	106	97	
82.0	105	102	99	43	227	110	102		102	91	98	70	199	106	97	
83.0	104	101	99	44	231	112	102		103	92	98	71	203	106	98	
84.0	105	101	99	44	234	113	102		103	92	98	71	206	107	99	
85.0	104	102	99	47	238	114	102		104	93	99	72	209	107	100	
86.0	104	101	98	46	242	116	102		104	94	99	73	212	108	100	
87.0	105	101	98	47	245	118	102		105	94	100	73	216	109	101	
88.0	105	101	98	48	249	120	102		105	95	100	73	219	110	101	
89.0	106	101	98	48	253	122	102		106	96	100	74	222	111	101	
90.0	106	101	98	47	257	124	102		106	96	100	75	226	112	101	
91.0	107	102	97	47	260	126	102		106	97	100	75	230	113	101	
92.0	107	102	97	49	264	128	102		107	98	101	76	233	114	102	
93.0	108	102	97	49	268	131	102		107	98	101	76	236	116	101	
94.0	109	102	97	49	272	133	102		108	99	101	77	240	117	101	
95.0	110	102	97	49	275	136	102		108	100	101	77	243	119	102	
96.0	111	101	97	50	279	138	102		109	101	101	78	247	120	101	
97.0	112	102	97	49	283	141	102		109	101	101	78	250	122	101	
98.0	113	102	97	50	286	143	102		110	102	101	78	254	125	102	
99.0	115	102	97	51	290	146	102		111	103	101	79	257	127	101	
100.0	116	102	96	50	294	148	102		111	103	102	79	261	129	101	
101.0	117	102	96	52	298	151	102		112	103	102	79	264	132	101	
102.0	118	102	96	51	302	153	102		113	103	102	80	268	134	101	
103.0	119	102	96	53	306	156	102		114	104	102	80	271	137	101	
104.0	120	102	96	53	309	158	102		114	104	102	79	274	139	101	
105.0	121	102	96	53	313	161	103		115	104	102	80	278	142	101	

TABLE 11
HEATING RATES OF GROUP B IN NW CONCRETE WITH HOLORIB DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION B1					TEMPERATURE (C) CONCRETE POSITION B2				
	2	6	8	12	14	2	6	8	12	
0.0	22	22	22	22	22	23	22	23	22	
2.0	22	23	22	22	22	23	23	23	23	
4.0	23	24	22	24	22	23	24	22	26	
6.0	24	27	22	26	22	25	30	23	31	
8.0	25	30	23	30	23	26	35	23	37	
10.0	27	34	23	33	23	28	41	24	45	
12.0	28	38	24	37	25	30	49	25	53	
14.0	30	41	25	41	26	33	57	26	61	
16.0	31	45	27	45	27	37	64	28	69	
18.0	33	50	28	50	29	41	73	30	74	
20.0	35	56	29	55	31	45	81	33	83	
22.0	38	67	31	61	33	49	87	36	90	
24.0	41	99	33	70	36	54	96	39	96	
26.0	44	107	37	80	39	58	101	43	102	
28.0	48	109	40	89	44	63	104	46	103	
30.0	53	112	45	96	51	67	107	50	107	
32.0	57	114	49	101	60	71	108	54	109	
34.0	62	116	55	106	71	75	109	58	111	
36.0	66	116	62	111	79	78	110	61	112	
38.0	71	116	68	114	86	82	110	64	113	
40.0	75	116	75	115	90	85	110	68	116	
41.0	77	113	77	115	91	86	110	69	118	
42.0	79	111	77	113	91	88	110	71	119	
43.0	80	110	78	113	91	90	112	73	121	
44.0	81	110	79	112	91	91	115	74	124	
45.0	82	109	80	112	92	93	117	76	127	
46.0	83	109	81	112	92	94	120	77	130	
47.0	84	109	83	112	93	95	123	79	133	
48.0	85	109	85	112	94	96	127	80	136	
49.0	87	109	88	112	95	97	130	82	140	
50.0	88	108	92	112	97	98	134	84	144	
51.0	89	108	98	112	98	99	139	85	148	
52.0	90	109	101	112	99	100	143	87	152	
53.0	91	109	102	112	100	101	147	88	156	
54.0	93	110	104	112	101	102	151	89	161	
55.0	93	112	105	113	101	103	155	91	165	
56.0	95	114	106	114	102	104	159	93	170	
57.0	96	117	106	116	102	105	163	95	174	
58.0	97	120	106	118	102	106	167	96	178	
59.0	98	123	107	120	103	107	171	98	182	
60.0	99	125	107	122	103	107	175	99	187	
61.0	100	128	107	125	103	107	179	100	191	
62.0	101	132	107	127	103	107	183	100	196	
63.0	102	135	107	130	104	107	187	101	200	
64.0	104	138	107	133	104	107	191	101	204	
65.0	105	142	107	137	105	107	195	102	208	
66.0	106	145	108	140	105	107	199	102	212	
67.0	107	149	108	144	105	107	203	103	216	
68.0	108	152	107	147	105	107	206	103	220	
69.0	109	156	107	150	106	108	210	103	225	
70.0	110	159	107	154	106	109	214	103	229	
71.0	111	163	108	157	106	111	218	104	233	
72.0	112	166	108	161	106	112	221	104	237	
73.0	113	170	108	164	106	114	225	104	241	
74.0	114	173	108	167	107	116	229	104	245	
75.0	115	177	108	171	107	117	232	104	249	
76.0	116	180	108	174	107	119	236	105	253	
77.0	117	183	108	178	107	121	239	105	258	
78.0	118	187	108	181	107	123	243	105	262	
79.0	119	191	109	184	108	125	247	105	266	
80.0	120	194	109	188	107	127	250	106	269	
81.0	121	197	108	191	107	130	254	106	273	
82.0	121	201	108	195	108	132	257	106	277	
83.0	122	204	108	198	108	134	261	106	281	
84.0	123	207	108	202	108	136	264	106	285	
85.0	125	211	108	205	108	138	268	106	289	
86.0	126	214	108	209	108	140	272	107	292	
87.0	127	217	108	212	108	142	275	108	296	
88.0	128	221	108	216	108	144	279	109	300	
89.0	130	224	108	219	109	146	282	110	304	
90.0	131	227	108	223	109	148	286	111	307	
91.0	133	231	109	227	110	150	289	112	311	
92.0	135	234	109	231	111	152	293	114	315	
93.0	136	237	110	234	113	153	296	115	319	
94.0	138	241	111	238	114	155	300	116	323	
95.0	140	244	112	242	116	157	303	117	326	
96.0	141	247	113	245	118	159	307	118	329	
97.0	143	251	114	249	119	161	310	119	333	
98.0	145	254	115	253	121	164	313	120	336	
99.0	147	258	116	257	123	165	317	122	340	
100.0	149	261	117	260	125	167	321	123	344	
101.0	150	265	118	264	127	169	324	124	347	
102.0	152	269	119	267	129	170	327	126	350	
103.0	154	272	120	271	130	173	330	127	354	
104.0	156	276	121	274	132	175	334	128	357	
105.0	158	279	123	278	134	177	337	130	361	

TABLE 12

HEATING RATES OF GROUP C IN NEW CONCRETE WITH HOLORIB DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION C1			TEMPERATURE (C) CONCRETE POSITION C2		
	10	12	14	2	12	14
0.0	23	23	23	23	23	23
2.0	23	25	22	24	26	23
4.0	23	30	22	26	33	23
6.0	23	36	23	29	41	23
8.0	23	41	23	32	51	24
10.0	23	47	25	35	62	26
12.0	24	54	26	38	71	28
14.0	25	60	28	42	81	31
16.0	26	68	30	47	97	34
18.0	27	77	32	55	106	39
20.0	29	89	35	63	109	47
22.0	30	106	39	69	110	59
24.0	32	110	45	74	110	66
26.0	34	114	57	79	111	70
28.0	37	115	77	83	113	74
30.0	40	116	98	88	119	78
32.0	42	117	107	93	130	83
34.0	44	117	113	97	143	88
36.0	46	122	114	101	158	91
38.0	48	130	114	105	174	93
40.0	51	141	114	108	190	95
41.0	52	143	110	108	198	96
42.0	53	147	108	109	207	97
43.0	54	152	107	110	215	98
44.0	55	156	107	112	223	99
45.0	56	160	107	114	232	100
46.0	56	165	107	116	240	101
47.0	57	169	107	118	248	102
48.0	58	174	107	120	255	103
49.0	59	179	107	123	263	105
50.0	60	184	107	126	271	105
51.0	60	189	107	128	278	106
52.0	61	194	107	130	285	106
53.0	62	199	107	133	293	107
54.0	63	205	106	135	300	107
55.0	63	210	106	137	301	107
56.0	64	215	106	140	314	107
57.0	65	220	106	142	321	107
58.0	65	225	106	145	328	107
59.0	66	231	106	147	335	108
60.0	67	236	106	150	342	108
61.0	67	241	106	153	348	108
62.0	68	246	106	155	355	109
63.0	69	251	106	158	362	109
64.0	70	256	106	161	368	110
65.0	70	260	106	164	375	111
66.0	71	265	106	167	381	112
67.0	72	270	106	170	388	113
68.0	72	274	106	173	394	115
69.0	73	279	106	176	400	117
70.0	74	283	106	178	406	120
71.0	75	288	106	181	412	122
72.0	76	292	106	184	418	125
73.0	77	297	106	187	424	128
74.0	79	302	106	189	430	131
75.0	80	306	106	192	436	134
76.0	81	311	107	195	441	137
77.0	83	316	108	198	447	140
78.0	84	320	109	201	452	143
79.0	85	325	111	204	458	146
80.0	87	330	113	207	463	149
81.0	89	335	114	210	469	152
82.0	91	340	116	213	474	155
83.0	94	345	118	216	479	158
84.0	97	349	121	219	484	161
85.0	98	354	123	222	489	164
86.0	99	359	127	225	494	167
87.0	100	364	129	228	499	170
88.0	101	370	132	231	504	173
89.0	101	374	135	234	508	175
90.0	101	379	138	237	513	178
91.0	102	384	141	240	517	181
92.0	103	390	144	243	522	184
93.0	103	395	147	246	526	186
94.0	104	400	150	249	530	189
95.0	105	405	152	252	535	192
96.0	105	410	155	255	539	195
97.0	106	415	158	258	544	198
98.0	107	421	160	261	548	201
99.0	108	426	163	264	553	203
100.0	108	431	166	266	557	207
101.0	110	436	169	269	562	210
102.0	110	441	171	272	566	213
103.0	111	446	174	275	570	216
104.0	112	451	177	278	574	218
105.0	113	456	179	281	578	221

TABLE 13
HEATING RATES OF GROUP A IN LW CONCRETE WITH HOLORIB DECK

DEPTH (m)	TEMPERATURE (C) CONCRETE POSITION A1							TEMPERATURE (C) CONCRETE POSITION A2						
	2	3	8	10	11	12	14	2	3	8	10	11	12	14
0.0	20	20	20	21	20	19	20	20	20	20	21	21	20	21
1.0	20	20	20	21	20	19	20	20	20	20	21	21	20	20
2.0	20	20	20	21	20	19	20	20	20	20	21	21	20	20
3.0	21	20	20	21	23	19	20	20	20	20	21	24	20	20
4.0	22	20	20	21	25	19	20	20	20	20	21	26	20	20
5.0	22	20	20	21	30	20	20	22	20	20	20	33	21	21
6.0	23	20	20	21	34	20	20	23	20	20	21	51	26	20
7.0	25	20	20	21	40	21	20	25	21	20	21	95	35	21
8.0	26	21	21	21	46	22	20	27	21	21	21	100	43	21
9.0	27	21	21	21	56	24	20	29	21	22	22	100	51	21
10.0	29	21	22	21	70	26	21	31	22	22	21	103	59	22
11.0	31	21	22	21	85	31	21	33	22	23	21	103	65	23
12.0	34	22	23	22	93	37	21	35	22	24	22	104	70	24
13.0	37	23	23	22	98	44	21	36	23	25	22	103	73	25
14.0	39	23	24	22	100	50	22	38	24	26	22	104	75	26
15.0	41	24	25	22	100	54	22	41	24	27	22	104	76	28
16.0	42	24	25	22	101	57	22	43	25	28	22	104	78	29
17.0	44	25	27	23	101	60	23	46	26	29	22	103	79	30
18.0	46	26	28	23	102	62	23	49	26	31	22	102	80	32
19.0	47	27	29	23	103	66	24	52	28	33	23	103	82	34
20.0	48	28	30	23	103	67	25	53	29	34	23	102	83	35
21.0	49	28	31	24	103	67	26	53	29	34	23	102	83	35
22.0	50	29	32	24	103	70	26	55	30	36	23	103	84	37
23.0	51	29	33	24	104	71	27	56	31	37	24	104	85	38
24.0	52	30	34	24	104	71	27	56	32	37	23	106	85	38
25.0	53	30	34	25	105	72	28	57	33	38	24	108	86	39
26.0	54	31	35	25	107	73	29	57	33	39	25	109	86	40
27.0	54	32	35	25	109	74	29	58	34	39	24	111	87	41
28.0	55	32	36	26	109	74	30	58	34	39	25	112	87	41
29.0	55	32	36	25	111	75	30	60	35	40	25	114	88	43
30.0	57	32	38	26	113	75	31	61	35	41	25	117	88	43
31.0	57	33	38	26	115	76	31	62	36	42	25	120	89	44
32.0	58	33	38	26	117	76	31	62	36	42	26	122	88	44
33.0	59	34	39	27	121	79	32	63	37	43	26	126	90	45
34.0	60	34	40	27	125	79	33	63	38	43	26	128	89	46
35.0	61	35	41	27	128	80	33	65	38	44	26	132	89	47
36.0	62	35	42	27	131	80	34	66	39	45	26	135	90	47
37.0	63	36	43	28	133	81	35	67	40	45	27	137	90	48
38.0	64	36	43	28	136	82	36	68	41	46	27	141	90	49
39.0	65	37	44	28	139	82	36	69	41	46	28	143	90	49
40.0	65	37	44	28	142	82	36	70	42	47	27	147	91	50
41.0	67	38	45	29	146	83	37	71	43	48	28	150	92	51
42.0	67	39	45	29	148	83	37	71	43	48	29	152	92	52
43.0	68	39	46	29	152	84	39	73	44	49	29	156	93	53
44.0	69	40	47	30	155	84	39	73	45	50	29	158	93	53
45.0	71	40	48	30	159	84	40	75	46	51	29	161	93	54
46.0	72	41	49	30	162	85	41	76	47	51	30	164	94	55
47.0	73	42	49	31	165	85	41	76	48	52	30	165	93	55
48.0	74	43	50	31	168	85	42	77	49	52	31	168	93	55
49.0	74	43	51	32	171	86	42	78	50	53	31	171	94	56
50.0	75	44	51	32	174	87	43	80	51	54	31	175	95	57
51.0	77	45	52	32	178	87	44	80	52	55	31	177	95	57
52.0	78	45	53	33	181	88	45	81	53	56	32	180	96	59
53.0	78	46	53	33	183	88	45	81	54	56	33	183	96	59
54.0	79	47	54	34	187	89	46	82	55	57	33	186	96	60
55.0	80	47	55	33	190	90	47	82	55	57	32	188	96	60
56.0	81	48	56	34	193	90	47	84	56	58	32	191	97	61
57.0	82	48	57	34	196	91	48	84	57	58	33	193	97	61
58.0	83	49	57	35	199	91	48	85	57	59	34	196	98	61
59.0	84	50	58	35	202	92	49	87	58	60	34	199	99	63
60.0	85	51	59	35	205	93	50	87	59	61	34	202	100	64
61.0	86	51	59	36	208	93	50	87	60	61	35	203	100	63
62.0	87	52	60	36	211	94	51	87	61	62	35	206	101	64
63.0	88	52	61	37	214	95	52	88	61	63	35	209	101	65
64.0	89	53	61	37	217	95	52	88	62	63	36	211	100	65
65.0	90	54	62	37	220	97	53	91	63	65	36	214	101	66
66.0	91	55	63	38	223	98	53	91	63	66	37	216	101	67
67.0	92	55	64	38	226	99	54	93	64	67	37	218	101	67
68.0	93	56	64	38	229	100	55	95	65	68	37	221	101	69
69.0	94	57	65	39	232	101	55	95	65	70	37	223	101	69
70.0	95	57	66	39	235	103	56	96	66	71	37	226	101	70
71.0	96	58	67	39	237	104	57	98	68	71	38	229	102	71
72.0	97	59	67	40	240	105	57	98	68	72	38	231	101	71
73.0	98	59	68	40	243	106	58	97	69	72	39	233	101	72
74.0	98	60	69	40	245	107	59	98	69	72	39	236	101	73
75.0	99	61	70	41	248	109	59	99	70	73	39	239	101	74
76.0	100	62	70	42	251	110	60	98	71	74	41	241	101	75
77.0	101	62	71	41	254	111	61	99	71	76	40	243	101	76
78.0	102	63	72	42	256	112	61	99	72	77	41	246	101	77
79.0	103	63	73	42	259	116	62	100	73	78	40	249	101	78
80.0	104	64	73	43	262	116	62	100	73	79	42	252	101	79
81.0	105	65	74	43	265	117	63	100	74	80	42	254	101	80
82.0	106	66	75	43	267	118	64	100	74	81	43	257	101	81
83.0	106	66	76	44	270	119	65	100	75	82	42	259	101	82
84.0	107	67	76	44	273	120	65	100	75	82	44	261	101	83
85.0	108	67	77	44	276	121	66	101	76	83	43	264	101	84

TABLE 14
HEATING RATES OF GROUP B IN LW CONCRETE WITH HOLORIB DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION B1					TEMPERATURE (C) CONCRETE POSITION B2				
	2	6	8	12	14	2	6	8	12	
0.0	20	20	20	20	20	21	22	21	22	
2.0	20	20	20	20	20	22	24	21	27	
4.0	21	20	20	21	20	23	32	21	36	
6.0	22	23	20	23	20	26	57	22	68	
8.0	23	25	20	25	20	28	98	22	90	
10.0	25	30	21	29	20	32	103	25	96	
12.0	26	32	20	32	20	36	102	27	96	
14.0	28	38	21	37	21	40	102	30	97	
16.0	30	43	22	41	21	44	103	31	99	
18.0	32	47	22	45	22	48	104	34	101	
20.0	34	52	23	51	22	52	105	37	103	
22.0	36	58	23	55	23	56	109	40	105	
24.0	39	64	25	60	24	60	114	43	110	
26.0	41	68	26	64	25	64	119	45	116	
28.0	43	71	27	69	26	69	126	48	126	
30.0	45	75	29	73	27	73	134	50	137	
32.0	48	81	30	82	28	77	143	52	147	
34.0	50	83	31	89	29	80	153	55	161	
36.0	53	87	33	93	31	83	163	57	176	
38.0	56	92	36	97	33	88	176	60	191	
40.0	59	93	38	96	35	90	187	62	205	
41.0	60	95	38	97	35	91	193	64	210	
42.0	62	98	40	98	37	93	201	65	218	
43.0	63	96	41	99	38	95	208	67	224	
44.0	64	97	42	99	39	96	215	68	230	
45.0	66	97	43	99	40	98	222	70	236	
46.0	67	98	45	99	41	100	228	71	242	
47.0	68	100	46	99	42	100	235	72	248	
48.0	69	100	46	98	42	100	240	73	252	
49.0	71	101	48	100	43	102	247	75	258	
50.0	72	101	48	100	44	102	253	78	263	
51.0	74	102	50	101	45	103	259	79	269	
52.0	74	101	50	100	45	102	263	81	273	
53.0	76	102	52	102	47	103	270	82	279	
54.0	77	101	52	101	48	103	274	84	284	
55.0	78	102	53	102	49	103	280	85	289	
56.0	79	102	55	103	51	104	285	85	295	
57.0	80	102	56	103	52	104	290	88	300	
58.0	81	103	57	103	53	105	296	90	306	
59.0	82	103	58	103	54	105	300	91	311	
60.0	83	104	59	103	55	106	305	92	316	
61.0	84	105	61	104	57	108	310	94	321	
62.0	85	106	63	104	58	108	315	94	326	
63.0	86	107	66	105	60	109	320	95	332	
64.0	87	108	68	106	62	110	324	96	336	
65.0	88	109	70	107	64	112	328	97	341	
66.0	89	110	72	108	65	114	333	98	345	
67.0	89	110	74	108	66	116	336	100	349	
68.0	90	111	76	108	67	118	340	101	353	
69.0	91	113	77	109	68	120	344	102	357	
70.0	92	115	79	109	70	122	348	103	361	
71.0	93	116	80	110	71	124	351	103	365	
72.0	94	118	82	109	72	126	355	104	369	
73.0	95	119	82	109	73	128	358	105	372	
74.0	96	121	84	110	74	130	362	106	376	
75.0	97	123	84	111	74	131	365	107	379	
76.0	97	125	85	110	76	133	368	108	383	
77.0	98	127	86	114	76	134	372	109	386	
78.0	99	129	86	108	77	136	375	110	390	
79.0	100	132	88	116	79	138	379	112	393	
80.0	101	134	88	120	80	140	383	113	397	
81.0	102	135	88	122	80	141	386	114	400	
82.0	103	137	89	123	81	144	390	115	403	
83.0	103	139	90	124	83	145	393	117	406	
84.0	104	141	89	125	83	147	396	118	409	
85.0	105	143	90	127	85	149	400	119	413	
86.0	106	145	90	128	85	151	403	119	416	
87.0	107	147	91	129	85	153	407	121	419	
88.0	108	149	91	131	86	155	411	122	422	
89.0	109	151	91	132	87	156	414	123	425	
90.0	110	154	92	134	89	158	418	124	428	
91.0	111	157	93	136	91	161	422	126	432	
92.0	112	159	93	137	92	162	425	127	435	
93.0	113	161	92	139	92	164	429	128	438	
94.0	114	163	93	140	92	166	432	129	441	
95.0	115	167	93	143	93	169	436	130	445	
96.0	115	169	93	144	93	170	440	132	448	
97.0	116	172	93	147	93	172	443	133	451	
98.0	118	175	94	149	94	175	447	134	455	
99.0	119	178	95	151	95	177	451	135	459	
100.0	119	181	95	153	95	179	455	137	462	
101.0	120	184	96	156	95	181	459	137	465	
102.0	121	187	96	158	95	182	462	139	469	
103.0	122	189	96	161	95	184	466	140	472	
104.0	123	192	96	163	95	186	470	140	475	
105.0	124	195	96	166	95	188	474	142	478	

TABLE 15
HEATING RATES IN GROUP C IN LW CONCRETE WITH HOLORIB DECK

TIME (min)	TEMPERATURE (C) CONCRETE POSITION C1			TEMPERATURE (C) CONCRETE POSITION C2		
	10	12	14	2	12	14
0.0	22	20	21	22	22	22
2.0	22	20	21	22	22	22
4.0	22	21	20	22	22	21
6.0	22	23	20	24	24	22
8.0	21	25	20	26	27	21
10.0	21	29	20	29	31	22
12.0	21	33	20	33	35	22
14.0	22	37	21	38	40	22
16.0	22	41	21	56	46	22
18.0	22	45	21	86	54	23
20.0	22	50	22	91	61	23
22.0	23	54	22	93	68	25
24.0	24	59	23	94	75	27
26.0	24	63	24	97	83	29
28.0	24	68	25	97	90	33
30.0	24	73	26	97	96	37
32.0	25	78	27	99	103	43
34.0	26	83	28	98	109	48
36.0	27	89	29	97	116	51
38.0	27	96	31	99	124	56
40.0	27	101	32	99	129	58
41.0	29	104	33	99	131	58
42.0	28	108	34	101	134	61
43.0	29	111	35	102	137	62
44.0	29	113	36	102	140	63
45.0	30	117	37	103	141	64
46.0	31	120	38	105	144	65
47.0	31	123	39	106	145	66
48.0	32	126	40	107	148	67
49.0	31	130	41	109	151	68
50.0	32	132	42	110	152	69
51.0	32	135	43	112	155	71
52.0	34	137	43	112	156	69
53.0	34	141	45	115	158	71
54.0	35	142	46	116	159	71
55.0	35	145	47	118	162	73
56.0	35	147	48	119	163	75
57.0	37	150	49	120	164	75
58.0	36	153	50	122	166	76
59.0	38	154	51	123	167	75
60.0	38	157	53	125	170	76
61.0	38	159	57	127	171	77
62.0	40	161	55	129	173	77
63.0	40	163	57	131	175	80
64.0	40	164	58	133	176	80
65.0	42	165	60	135	178	81
66.0	42	167	61	136	179	83
67.0	42	167	62	137	179	81
68.0	44	169	63	139	181	83
69.0	44	171	65	142	182	84
70.0	44	172	66	144	183	85
71.0	45	173	67	145	185	86
72.0	47	175	69	148	187	87
73.0	47	176	70	150	188	87
74.0	48	177	72	152	190	88
75.0	48	177	72	153	191	88
76.0	48	178	74	155	192	90
77.0	50	178	75	157	194	91
78.0	50	179	76	159	197	91
79.0	51	181	78	161	200	93
80.0	51	182	80	163	203	94
81.0	52	183	80	164	205	94
82.0	52	185	81	166	210	95
83.0	53	188	83	168	215	95
84.0	54	190	83	169	219	94
85.0	55	193	85	171	225	97
86.0	55	196	86	173	229	97
87.0	56	200	87	174	234	97
88.0	56	204	89	177	239	98
89.0	57	208	89	178	244	99
90.0	57	213	91	180	250	100
91.0	58	218	93	182	255	102
92.0	58	222	93	183	260	102
93.0	60	226	94	185	265	102
94.0	61	230	95	186	269	103
95.0	60	235	97	188	275	104
96.0	62	239	97	190	280	104
97.0	61	243	99	191	284	105
98.0	63	248	100	193	290	106
99.0	63	253	101	195	295	107
100.0	64	257	102	197	299	108
101.0	64	261	103	199	304	108
102.0	65	265	104	201	309	109
103.0	65	269	105	202	313	109
104.0	67	273	106	204	318	109
105.0	66	278	107	206	323	110

TABLE 16
HEATING RATES OF SHEAR STUD CONNECTORS

TIME (min)	STUD TEMPERATURE (C)			
	NORMAL WEIGHT		LIGHT WEIGHT	
	HEAD	SHANK	HEAD	SHANK
0.0	21	22	22	22
2.0	22	22	21	20
4.0	22	22	21	21
6.0	22	22	21	20
8.0	22	22	22	21
10.0	21	22	22	23
12.0	22	23	23	23
14.0	23	25	23	23
16.0	24	26	24	25
18.0	23	27	26	29
20.0	26	29	27	29
22.0	26	31	29	34
24.0	28	33	31	37
26.0	30	36	32	39
28.0	32	39	34	42
30.0	34	42	36	44
32.0	37	45	38	47
34.0	40	48	40	49
36.0	42	51	41	51
38.0	44	53	43	53
40.0	47	56	44	55
41.0	48	57	46	57
42.0	49	59	47	58
43.0	50	60	48	59
44.0	52	62	48	60
45.0	53	63	49	62
46.0	53	64	50	63
47.0	54	65	53	65
48.0	56	67	53	66
49.0	57	68	54	67
50.0	59	70	55	69
51.0	60	71	56	70
52.0	61	72	57	72
53.0	62	74	58	73
54.0	63	76	60	75
55.0	65	77	61	77
56.0	67	79	63	79
57.0	69	80	64	80
58.0	70	81	66	82
59.0	71	83	66	84
60.0	72	83	68	85
61.0	74	85	68	86
62.0	73	86	71	89
63.0	76	87	72	90
64.0	77	89	72	91
65.0	77	90	74	92
66.0	79	91	76	94
67.0	79	93	77	95
68.0	82	94	78	97
69.0	81	97	79	98
70.0	83	99	80	100
71.0	86	100	81	101
72.0	86	101	83	102
73.0	88	102	84	102
74.0	87	102	86	104
75.0	88	102	88	105
76.0	89	103	89	106
77.0	92	104	90	107
78.0	93	105	91	108
79.0	94	106	93	110
80.0	95	108	94	111
81.0	96	109	95	112
82.0	96	109	97	113
83.0	99	112	97	114
84.0	99	113	99	115
85.0	99	115	100	117
86.0	101	116	101	119
87.0	101	118	102	120
88.0	102	119	103	122
89.0	103	120	103	123
90.0	103	122	104	124
91.0	104	124	105	126
92.0	106	125	105	127
93.0	107	126	107	128
94.0	108	128	108	130
95.0	108	130	108	131
96.0	109	131	110	132
97.0	110	133	112	134
98.0	112	135	112	135
99.0	113	136	114	137
100.0	115	138	115	138
101.0	115	139	117	140
102.0	117	141	118	141
103.0	112	142	120	143
104.0	119	144	121	144
105.0	120	145	122	146

TABLE 17
HEATING RATES OF ADDITIONAL REINFORCING MESH

TIME (min)	TEMPERATURE (C) MESH POSITION (NW)					TEMPERATURE (C) MESH POSITION (LW)				
	1	2	3	4	5	6	7	8	9	10
0.0	23	22	22	23	23	22	22	22	23	22
2.0	32	23	36	25	24	22	21	21	21	21
4.0	37	24	42	28	26	25	21	23	22	22
6.0	46	27	49	34	29	27	21	23	23	22
8.0	52	30	53	39	33	31	22	25	25	23
10.0	59	34	59	46	38	33	22	26	27	24
12.0	66	38	66	51	42	36	22	28	30	26
14.0	73	43	75	58	48	38	22	29	32	28
16.0	81	48	79	64	53	41	23	30	37	30
18.0	87	51	84	68	57	46	24	34	43	35
20.0	94	57	91	75	64	48	24	35	45	37
22.0	98	61	91	78	69	53	27	39	51	43
24.0	104	66	94	83	73	56	28	43	55	49
26.0	111	70	97	88	78	58	29	46	58	58
28.0	117	74	100	92	82	62	30	49	62	66
30.0	123	79	104	98	86	64	31	50	66	71
32.0	128	83	106	102	90	68	34	53	69	76
34.0	134	88	109	106	95	70	35	54	75	81
36.0	141	93	113	110	100	72	36	57	79	85
38.0	146	97	116	114	104	75	38	59	83	90
40.0	152	102	120	120	109	77	39	60	86	93
41.0	154	104	122	122	111	79	41	61	89	96
42.0	157	107	125	126	113	81	42	61	91	98
43.0	160	110	127	128	114	82	43	62	93	99
44.0	163	113	129	132	117	83	44	63	94	100
45.0	166	116	132	134	118	84	45	64	96	101
46.0	169	119	134	136	120	86	46	66	98	103
47.0	172	120	135	137	121	89	49	69	102	104
48.0	176	124	137	139	123	90	49	69	102	104
49.0	179	126	140	139	125	92	50	70	104	104
50.0	183	129	143	141	127	93	51	71	104	104
51.0	186	130	144	141	130	95	52	73	106	104
52.0	189	132	147	142	134	97	53	74	107	104
53.0	193	133	149	143	133	98	55	75	109	104
54.0	197	133	151	145	131	100	56	77	110	104
55.0	200	133	153	147	131	102	58	79	113	105
56.0	204	133	153	150	132	104	59	80	115	105
57.0	208	133	156	155	135	105	60	81	116	105
58.0	212	132	157	159	137	107	62	83	119	106
59.0	216	132	160	164	140	108	62	83	119	106
60.0	220	132	162	168	143	110	64	85	122	107
61.0	225	133	166	174	146	117	64	85	122	107
62.0	228	134	167	178	149	113	67	88	126	109
63.0	233	136	170	183	152	113	68	88	127	109
64.0	237	139	173	187	156	114	68	89	128	111
65.0	242	141	175	192	160	116	70	90	129	112
66.0	246	144	177	197	165	118	72	92	132	113
67.0	251	147	179	202	170	120	73	92	133	115
68.0	255	150	181	207	175	121	75	93	135	117
69.0	261	153	184	211	180	122	76	93	136	118
70.0	265	156	186	216	185	124	77	95	138	120
71.0	271	159	188	221	191	124	79	95	139	122
72.0	276	162	190	226	196	127	80	96	141	125
73.0	283	165	192	231	201	127	81	97	141	126
74.0	288	168	194	236	206	129	83	98	144	128
75.0	294	171	196	241	211	131	85	100	147	130
76.0	299	174	198	246	216	133	87	101	148	132
77.0	305	178	201	251	221	133	87	101	149	133
78.0	311	181	203	255	226	134	88	102	151	134
79.0	317	184	205	261	231	136	90	102	152	136
80.0	322	187	207	266	235	137	91	103	154	137
81.0	327	190	210	270	240	137	92	104	155	139
82.0	332	193	212	276	244	139	94	105	158	140
83.0	337	196	214	282	249	139	94	104	158	141
84.0	342	199	217	287	253	141	96	105	160	142
85.0	347	203	219	293	257	141	97	106	161	143
86.0	352	206	222	299	262	143	99	107	164	145
87.0	357	209	224	305	267	143	100	107	165	146
88.0	361	212	226	310	271	146	101	108	168	148
89.0	366	215	229	316	274	146	101	108	169	149
90.0	371	218	231	321	279	147	103	109	170	150
91.0	376	221	234	326	284	148	105	109	172	152
92.0	380	224	233	331	288	149	105	109	173	153
93.0	385	227	238	336	292	151	106	110	175	156
94.0	389	230	241	341	296	152	106	111	176	158
95.0	394	233	244	346	301	153	108	111	178	159
96.0	398	236	247	351	305	154	109	112	180	162
97.0	403	239	250	355	309	156	107	112	182	164
98.0	407	243	253	360	314	157	107	113	183	165
99.0	412	245	254	364	317	159	110	114	186	168
100.0	417	249	256	369	322	160	112	115	188	170
101.0	421	252	260	374	326	161	113	115	190	172
102.0	425	255	264	378	330	163	114	116	193	174
103.0	429	258	269	382	334	165	116	118	196	177
104.0	433	261	274	387	339	164	117	118	197	179
105.0	438	264	280	390	343	168	120	119	201	182

TABLE 18
HEATING RATE OF STEEL BEAM UNDER PMF DECK WITH NW CONCRETE

TIME (min)	TEMPERATURE (C)							
	STEEL BEAM (NW PMF)							
	LF	U1	U2	U3	UF1	UF2	UF3 *	UF4 *
0.0	24	23	23	24	23	23	23	23
2.0	23	23	23	23	22	23	35	36
4.0	25	24	24	23	23	25	44	46
6.0	30	27	28	28	26	29	54	56
8.0	38	33	34	34	31	32	61	63
10.0	46	41	41	42	35	36	68	71
12.0	53	50	49	49	39	40	77	80
14.0	60	58	56	57	43	45	87	90
16.0	68	67	64	64	48	50	96	98
18.0	77	75	72	73	53	56	105	107
20.0	85	83	79	79	59	62	115	118
22.0	93	91	86	86	65	68	127	130
24.0	99	97	92	94	71	75	138	142
26.0	101	100	98	97	77	81	149	153
28.0	101	101	101	101	82	87	159	164
30.0	107	101	103	102	88	93	169	175
32.0	117	102	104	103	92	97	179	185
34.0	128	106	106	105	96	102	189	195
36.0	139	114	112	112	99	109	199	205
38.0	149	125	120	121	101	114	208	215
40.0	159	136	129	130	106	119	219	225
41.0	164	142	134	135	109	121	223	230
42.0	169	148	139	142	112	123	229	235
43.0	174	154	144	146	114	125	233	240
44.0	179	160	149	151	117	128	238	244
45.0	184	166	154	156	121	130	243	249
46.0	189	172	159	163	124	132	248	253
47.0	194	178	164	166	127	135	252	257
48.0	200	183	169	171	129	137	257	261
49.0	205	190	174	178	132	140	262	266
50.0	210	195	179	182	135	143	267	271
51.0	216	201	184	188	138	146	272	275
52.0	221	207	189	192	140	149	277	280
53.0	227	213	194	199	143	152	282	285
54.0	232	219	199	202	146	155	287	289
55.0	238	225	205	207	149	158	291	294
56.0	243	231	210	213	152	161	296	298
57.0	249	237	215	218	155	165	301	302
58.0	255	243	220	223	158	168	306	307
59.0	260	249	225	228	162	172	311	312
60.0	266	254	230	233	165	175	315	316
61.0	272	260	235	238	168	178	320	321
62.0	278	266	241	245	171	182	325	325
63.0	284	272	246	249	174	185	330	330
64.0	289	278	250	254	178	189	335	335
65.0	295	283	256	260	181	192	340	340
66.0	301	289	261	264	185	196	344	344
67.0	306	295	266	270	188	200	349	348
68.0	312	300	270	274	191	203	353	353
69.0	318	306	276	280	195	207	358	357
70.0	324	312	281	285	198	210	363	361
71.0	330	317	285	289	202	214	367	366
72.0	336	323	290	294	205	217	372	370
73.0	341	329	295	300	209	221	376	374
74.0	347	335	300	304	212	225	381	378
75.0	353	340	305	309	216	228	385	383
76.0	358	346	310	313	219	232	389	387
77.0	364	351	315	318	223	236	394	391
78.0	370	356	320	324	226	239	399	396
79.0	376	362	325	328	230	243	403	400
80.0	381	367	330	334	233	246	407	404
81.0	387	373	334	338	236	250	412	409
82.0	392	378	339	342	240	254	416	413
83.0	398	383	344	347	243	257	421	417
84.0	403	389	348	352	247	261	425	421
85.0	409	394	353	358	250	264	429	426
86.0	414	399	358	361	254	268	433	429
87.0	419	404	362	367	257	272	437	433
88.0	425	409	367	371	261	275	442	437
89.0	430	414	372	377	264	279	446	441
90.0	435	420	376	381	267	283	450	445
91.0	441	425	381	386	271	286	454	449
92.0	446	430	385	389	274	290	458	453
93.0	451	434	390	394	277	293	462	456
94.0	456	439	394	398	281	297	466	460
95.0	461	444	399	403	284	300	470	465
96.0	466	449	403	407	287	304	474	468
97.0	471	454	407	413	291	307	478	472
98.0	476	459	412	417	294	311	482	475
99.0	481	464	416	422	297	314	486	479
100.0	486	468	420	425	301	318	490	483
101.0	491	473	425	429	304	321	494	486
102.0	496	478	429	433	307	325	497	490
103.0	501	482	433	437	310	328	501	494
104.0	505	487	437	442	313	332	505	497
105.0	510	491	441	446	317	335	508	501

* Unfilled void

TABLE 19
HEATING RATES OF STEEL BEAM UNDER PMF DECK WITH LW CONCRETE

TIME (min)	TEMPERATURE (C)							
	STEEL BEAM (LW PMF)							
	LF	W1	W2	W3	UF1	UF2	UF3 *	UF4 *
0.0	23	22	22	22	22	22	23	23
2.0	23	23	22	22	23	23	38	33
4.0	27	27	23	24	26	26	50	43
6.0	33	32	27	28	30	32	61	55
8.0	41	40	33	36	35	36	70	64
10.0	48	48	40	44	40	40	80	70
12.0	57	57	48	53	46	46	91	78
14.0	66	66	56	61	51	53	101	87
16.0	75	76	64	70	57	59	111	97
18.0	84	85	72	77	64	66	122	108
20.0	93	94	80	86	71	73	135	119
22.0	99	100	88	93	78	80	149	131
24.0	107	105	94	99	85	86	162	143
26.0	115	111	98	101	91	92	174	156
28.0	125	117	100	102	97	97	186	167
30.0	135	125	100	103	103	103	198	178
32.0	145	135	102	112	113	112	209	189
34.0	156	146	110	124	122	120	220	200
36.0	167	157	120	136	130	128	230	209
38.0	178	169	131	149	137	136	241	219
40.0	190	181	143	162	143	143	252	229
41.0	196	187	148	168	146	146	258	234
42.0	202	193	154	174	149	150	263	239
43.0	208	199	160	180	153	153	269	243
44.0	214	206	167	186	156	157	275	248
45.0	220	213	173	193	160	161	281	253
46.0	226	219	179	199	163	164	287	259
47.0	232	225	185	205	167	168	292	264
48.0	238	232	191	211	170	172	298	269
49.0	244	238	196	216	174	176	303	274
50.0	250	245	203	223	178	180	309	279
51.0	256	251	208	228	182	183	315	284
52.0	263	257	214	234	186	187	321	289
53.0	269	263	220	240	190	191	326	294
54.0	275	270	226	246	193	195	331	299
55.0	281	276	232	252	197	199	337	304
56.0	287	283	237	257	201	203	343	308
57.0	294	290	244	264	205	207	348	312
58.0	300	296	249	269	209	211	353	317
59.0	306	302	255	275	213	215	359	322
60.0	312	308	260	280	217	219	364	328
61.0	319	315	266	286	221	223	370	333
62.0	324	321	271	292	225	227	375	338
63.0	331	327	277	297	229	231	380	342
64.0	337	333	283	303	233	235	386	348
65.0	343	340	288	308	237	239	391	352
66.0	349	346	294	314	241	243	396	357
67.0	356	352	299	320	245	247	401	362
68.0	362	358	305	325	249	251	406	367
69.0	368	364	310	330	253	255	411	372
70.0	374	370	315	336	257	259	416	377
71.0	380	376	321	341	261	263	421	382
72.0	386	382	326	346	265	268	426	386
73.0	392	388	331	352	269	272	431	391
74.0	398	394	336	357	273	276	436	396
75.0	404	400	341	362	277	280	441	400
76.0	410	406	347	367	281	284	446	405
77.0	416	412	352	372	285	288	451	409
78.0	422	417	357	378	288	292	455	414
79.0	427	423	361	382	292	296	460	418
80.0	433	428	367	387	296	300	464	423
81.0	439	434	372	393	300	304	469	427
82.0	445	439	376	397	304	308	473	432
83.0	450	445	381	402	307	312	478	436
84.0	456	450	386	407	311	315	482	440
85.0	461	456	391	412	315	319	487	445
86.0	467	461	396	417	319	323	491	449
87.0	472	467	400	422	322	327	496	454
88.0	478	472	405	426	326	331	500	458
89.0	483	477	410	431	330	335	505	462
90.0	489	482	414	436	333	338	509	466
91.0	494	487	419	440	337	342	514	470
92.0	499	493	423	445	341	346	518	474
93.0	504	498	428	450	344	349	523	478
94.0	510	503	432	454	348	353	527	483
95.0	515	508	437	459	351	357	531	486
96.0	520	512	441	463	355	361	535	490
97.0	525	517	445	467	359	364	540	495
98.0	530	522	450	472	362	368	544	499
99.0	535	526	454	476	366	371	548	503
100.0	540	531	458	480	369	375	553	507
101.0	544	536	462	484	373	379	557	511
102.0	549	540	466	489	376	382	561	515
103.0	554	545	471	493	379	385	566	519
104.0	559	549	475	497	383	389	570	523
105.0	563	554	479	501	386	392	574	528

* Unfilled void

TABLE 20
HEATING RATE OF STEEL BEAM UNDER HOLORIB DECK WITH NW CONCRETE

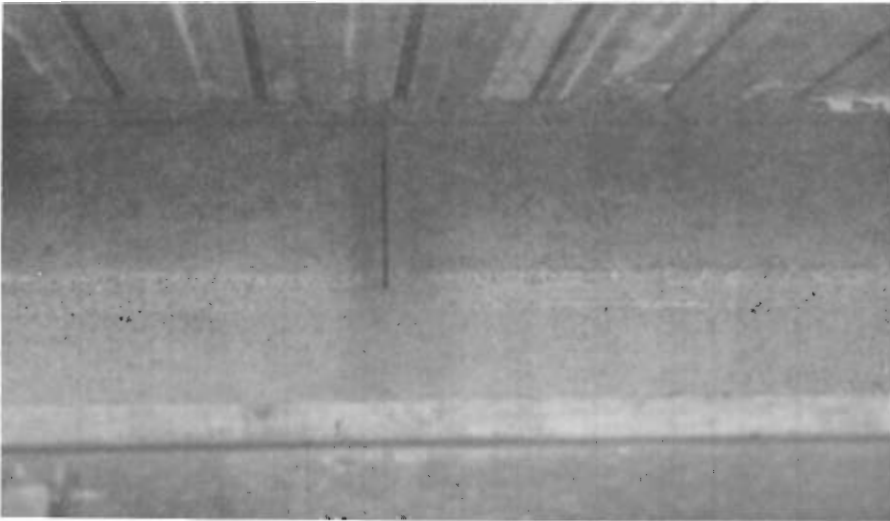
TIME (min)	TEMPERATURE (C)							
	STEEL BEAM (NW HOLORIB)							
	LF	U1	U2	U3	UF1	UF2	UF3 *	UF4 *
0.0	23	23	23	23	23	22	23	23
2.0	24	23	23	23	23	27	24	25
4.0	27	25	24	26	26	36	28	29
6.0	33	29	28	31	30	44	34	36
8.0	41	36	34	39	34	49	40	43
10.0	48	43	42	47	39	54	46	49
12.0	56	52	50	55	44	61	54	56
14.0	65	60	57	64	50	69	62	64
16.0	74	69	65	72	56	80	70	71
18.0	83	77	73	79	63	92	77	77
20.0	92	86	80	87	71	103	83	83
22.0	98	93	88	95	79	113	89	89
24.0	103	99	95	100	85	122	94	93
26.0	110	101	99	103	92	130	100	98
28.0	120	101	101	105	98	138	109	104
30.0	130	103	102	108	102	148	118	113
32.0	140	109	103	119	109	156	126	121
34.0	149	119	110	131	117	164	133	127
36.0	160	130	121	143	124	171	139	133
38.0	170	143	133	155	130	178	144	139
40.0	181	155	145	168	137	185	150	144
41.0	187	162	150	174	140	189	152	147
42.0	192	168	156	180	143	194	156	150
43.0	198	174	162	186	146	198	159	153
44.0	204	181	168	192	150	202	162	156
45.0	210	187	174	198	153	207	166	159
46.0	216	194	180	204	157	211	169	163
47.0	222	200	186	210	160	215	173	166
48.0	228	207	192	217	164	219	176	169
49.0	234	213	198	223	168	223	180	173
50.0	240	220	204	229	172	228	184	176
51.0	246	226	210	234	176	232	188	180
52.0	253	233	215	240	180	236	191	183
53.0	259	240	221	246	183	240	195	187
54.0	265	246	227	252	187	244	199	190
55.0	271	252	233	258	191	247	203	194
56.0	277	259	239	264	195	251	207	197
57.0	284	265	245	270	199	255	211	201
58.0	290	272	250	275	203	259	214	204
59.0	296	278	256	281	207	263	218	208
60.0	302	285	262	287	210	266	222	211
61.0	309	291	268	292	214	270	226	215
62.0	315	297	273	298	218	274	230	218
63.0	321	304	279	303	222	278	234	222
64.0	327	310	284	309	226	282	238	225
65.0	334	316	290	314	229	285	242	229
66.0	340	322	295	320	233	289	245	232
67.0	346	328	301	325	237	293	249	236
68.0	352	335	306	330	241	296	253	240
69.0	359	341	312	335	245	300	257	243
70.0	365	347	317	341	248	304	261	247
71.0	371	353	322	346	252	307	265	250
72.0	377	359	327	351	256	311	269	254
73.0	383	365	333	356	260	314	273	257
74.0	389	371	338	361	263	318	277	261
75.0	395	377	343	366	267	322	281	265
76.0	401	382	348	371	270	325	285	268
77.0	407	388	353	376	274	329	289	272
78.0	413	394	358	381	278	332	292	275
79.0	418	399	363	386	281	336	296	279
80.0	424	405	368	391	285	339	300	282
81.0	430	410	373	396	288	343	304	286
82.0	436	416	378	401	292	347	308	289
83.0	441	421	383	405	295	350	311	293
84.0	447	427	388	410	299	353	315	296
85.0	452	432	392	415	302	357	319	300
86.0	458	437	397	419	306	361	322	303
87.0	463	443	402	424	309	364	326	306
88.0	469	448	406	429	313	368	330	310
89.0	474	453	411	433	316	371	333	313
90.0	480	458	416	438	320	375	337	317
91.0	485	463	420	442	323	378	340	320
92.0	490	468	425	447	326	382	344	324
93.0	495	473	429	451	330	386	347	327
94.0	501	478	434	456	333	389	351	330
95.0	506	483	438	460	336	393	355	334
96.0	511	488	442	464	340	396	358	337
97.0	516	493	447	468	343	400	362	341
98.0	521	498	451	473	346	403	365	344
99.0	526	502	455	477	350	407	369	348
100.0	531	507	460	481	353	410	372	351
101.0	536	512	464	485	356	414	376	354
102.0	540	516	468	490	360	417	379	358
103.0	545	521	472	494	363	421	383	361
104.0	550	525	476	498	366	424	386	364
105.0	555	530	480	502	369	428	390	368

* Unfilled void

TABLE 21
HEATING RATES OF STEEL BEAM UNDER HOLORIB DECK WITH LW CONCRETE

TIME (min)	TEMPERATURE (C)							
	STEEL BEAM (LW HOLORIB)							
	LF	W1	W2	W3	UF1	UF2	UF3 *	UF4 *
0.0	23	23	22	22	22	22	22	22
2.0	22	22	22	21	21	22	24	25
4.0	24	23	23	23	23	25	28	30
6.0	26	26	27	26	26	30	35	37
8.0	32	32	34	33	30	35	42	44
10.0	40	40	42	40	36	41	48	50
12.0	46	48	50	48	42	46	55	57
14.0	54	57	58	56	50	52	62	64
16.0	61	66	67	64	58	61	69	71
18.0	70	74	76	73	66	72	77	79
20.0	77	82	83	80	73	81	85	86
22.0	86	90	91	88	81	89	92	93
24.0	93	96	97	95	87	96	98	101
26.0	97	100	99	99	93	100	106	109
28.0	99	100	100	100	98	104	116	117
30.0	100	100	101	100	100	109	125	124
32.0	102	101	103	101	103	114	133	131
34.0	108	103	108	106	106	120	140	138
36.0	115	110	116	115	109	126	146	143
38.0	125	120	127	125	116	132	153	148
40.0	133	130	137	135	121	137	158	154
41.0	138	136	143	140	124	140	161	157
42.0	143	142	149	145	127	143	165	160
43.0	148	148	154	151	130	146	168	163
44.0	152	153	159	155	133	149	170	166
45.0	157	159	164	160	136	152	174	169
46.0	162	165	170	165	139	154	177	172
47.0	168	172	176	171	143	158	181	176
48.0	172	177	181	176	146	160	184	179
49.0	177	183	186	181	150	164	187	183
50.0	182	189	191	186	153	166	190	186
51.0	188	195	197	192	157	170	194	190
52.0	193	201	202	196	160	173	198	193
53.0	199	207	208	202	163	176	201	197
54.0	204	213	213	207	167	179	205	201
55.0	210	220	219	213	171	183	209	205
56.0	215	226	224	218	174	187	212	209
57.0	220	231	229	223	178	190	216	212
58.0	227	238	235	229	182	194	219	217
59.0	232	243	239	233	185	197	223	220
60.0	238	250	245	239	189	202	226	224
61.0	243	255	250	244	193	205	230	228
62.0	249	261	255	249	197	209	233	232
63.0	255	267	260	255	200	213	237	236
64.0	261	273	265	259	204	216	240	239
65.0	267	278	270	264	208	220	244	243
66.0	273	285	276	270	212	224	248	248
67.0	279	290	281	275	216	228	251	251
68.0	284	296	286	280	219	231	255	255
69.0	290	302	291	285	223	235	259	259
70.0	297	308	297	291	227	239	263	263
71.0	302	313	301	295	230	243	266	267
72.0	308	320	307	301	234	246	270	271
73.0	314	325	311	305	238	250	274	274
74.0	320	331	317	311	241	254	277	278
75.0	327	337	322	316	245	258	281	282
76.0	332	343	327	321	248	261	285	286
77.0	338	348	331	325	251	265	289	289
78.0	344	354	336	330	255	268	292	293
79.0	349	359	341	335	258	272	295	296
80.0	356	364	346	340	262	275	299	300
81.0	361	370	350	344	265	279	303	303
82.0	367	375	356	350	269	282	306	307
83.0	373	380	360	354	271	285	310	309
84.0	378	386	364	358	275	289	313	313
85.0	383	391	369	363	278	292	316	316
86.0	389	396	374	368	281	296	320	320
87.0	395	402	379	372	285	299	323	323
88.0	401	407	384	377	288	302	327	327
89.0	406	412	388	381	291	305	330	329
90.0	411	417	393	386	294	308	333	333
91.0	417	422	397	390	297	312	337	336
92.0	422	427	401	395	300	315	340	339
93.0	427	432	405	399	303	318	344	343
94.0	432	437	410	403	307	321	347	346
95.0	438	442	414	408	309	324	350	349
96.0	442	446	418	412	313	327	354	352
97.0	448	451	423	416	316	330	357	356
98.0	452	456	427	420	318	333	360	359
99.0	458	461	431	424	321	336	363	362
100.0	462	465	435	428	324	339	367	366
101.0	467	470	439	433	327	342	370	369
102.0	472	474	443	437	330	345	373	372
103.0	478	479	448	441	333	348	377	376
104.0	482	484	451	444	336	350	380	378
105.0	488	489	456	449	339	354	383	382

* Unfilled void



Thermal break in beam (a)



Position of beams and decking (b)



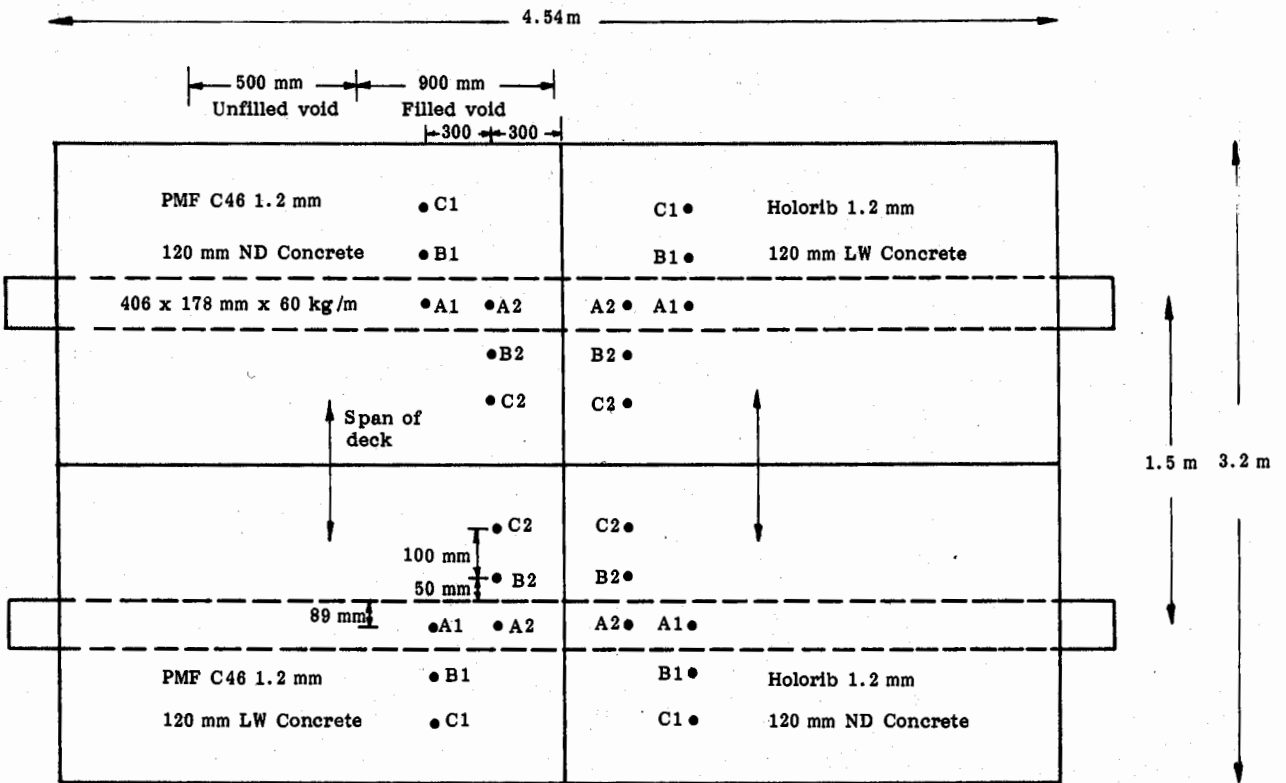
Orientation of deck span to beams (c)

FIG. 1



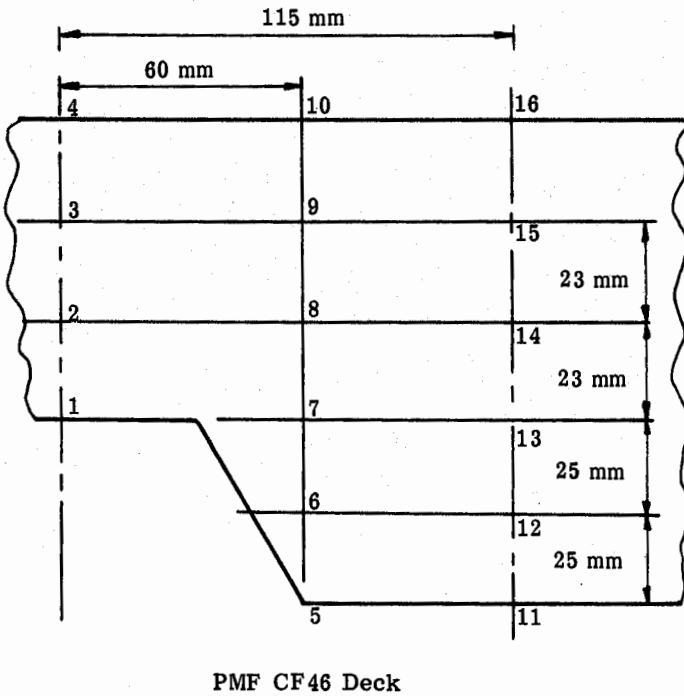
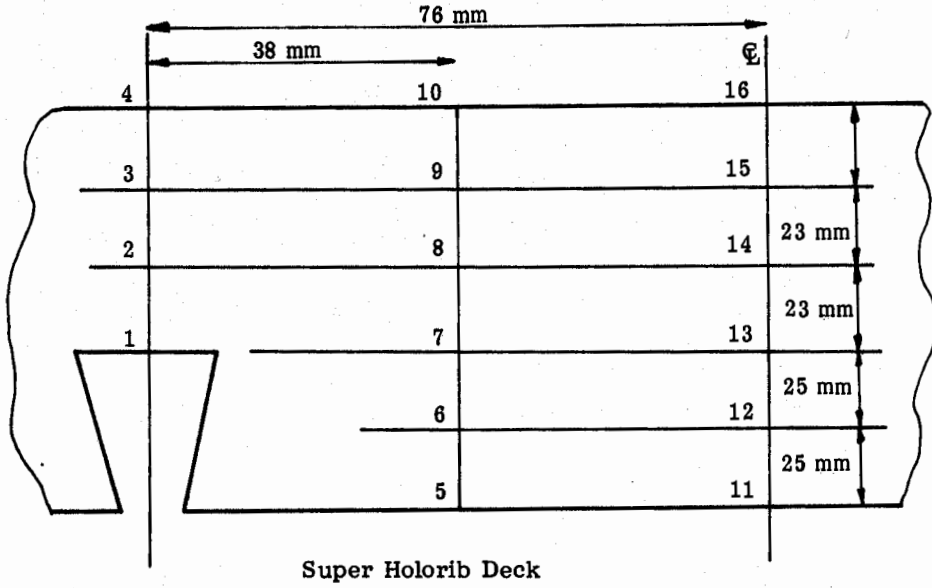
STUD WELDING SHEAR CONNECTORS

FIG. 2



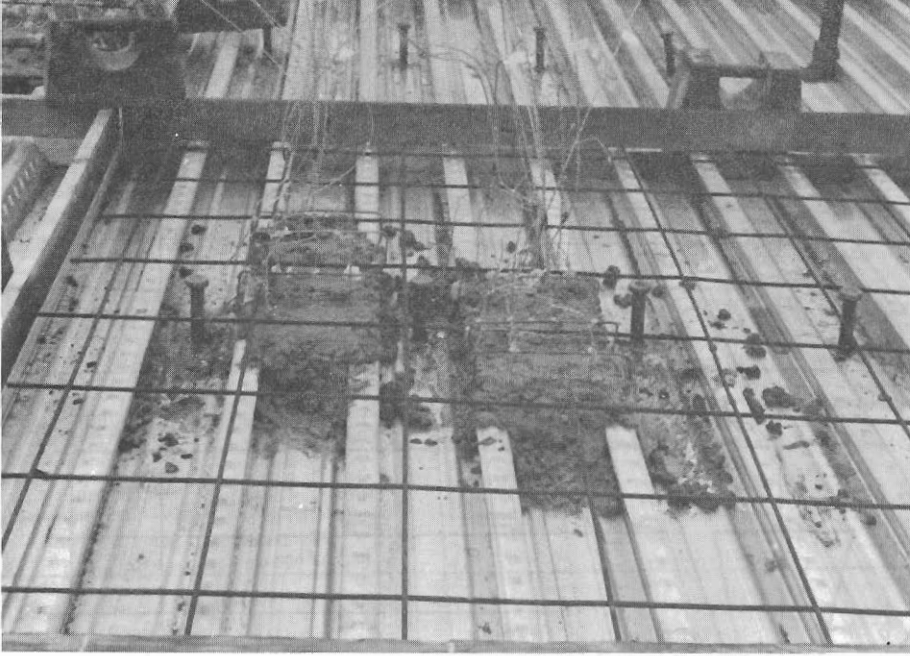
SCHEMATIC LAYOUT OF TEST ARRANGEMENT

FIG. 3
(R2/8957)



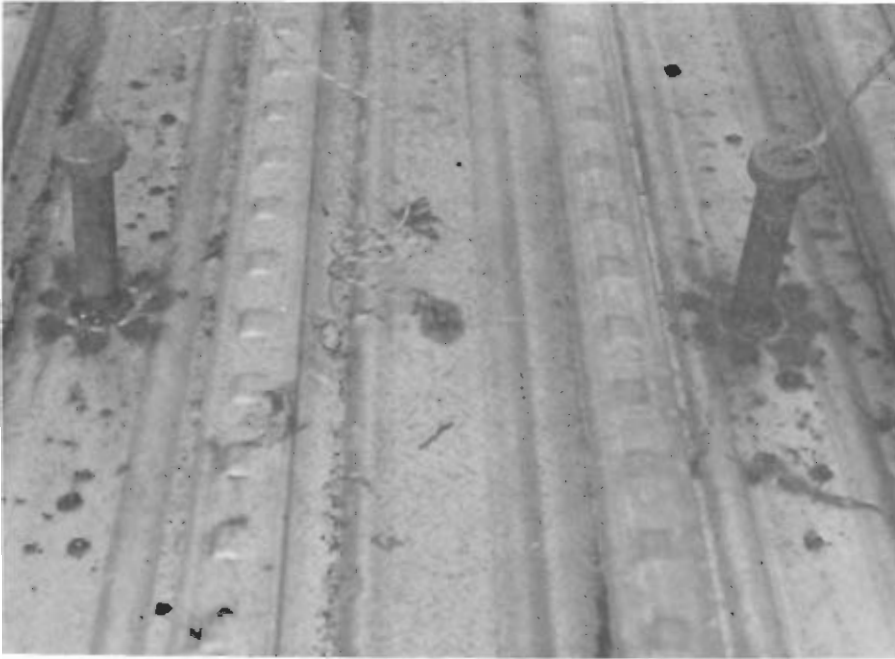
THERMOCOUPLE POSITIONS IN CONCRETE SLAB

FIG. 4
(R2/8958)



POSITIONING OF THERMOCOUPLES WITHIN THE CONCRETE

FIG. 5

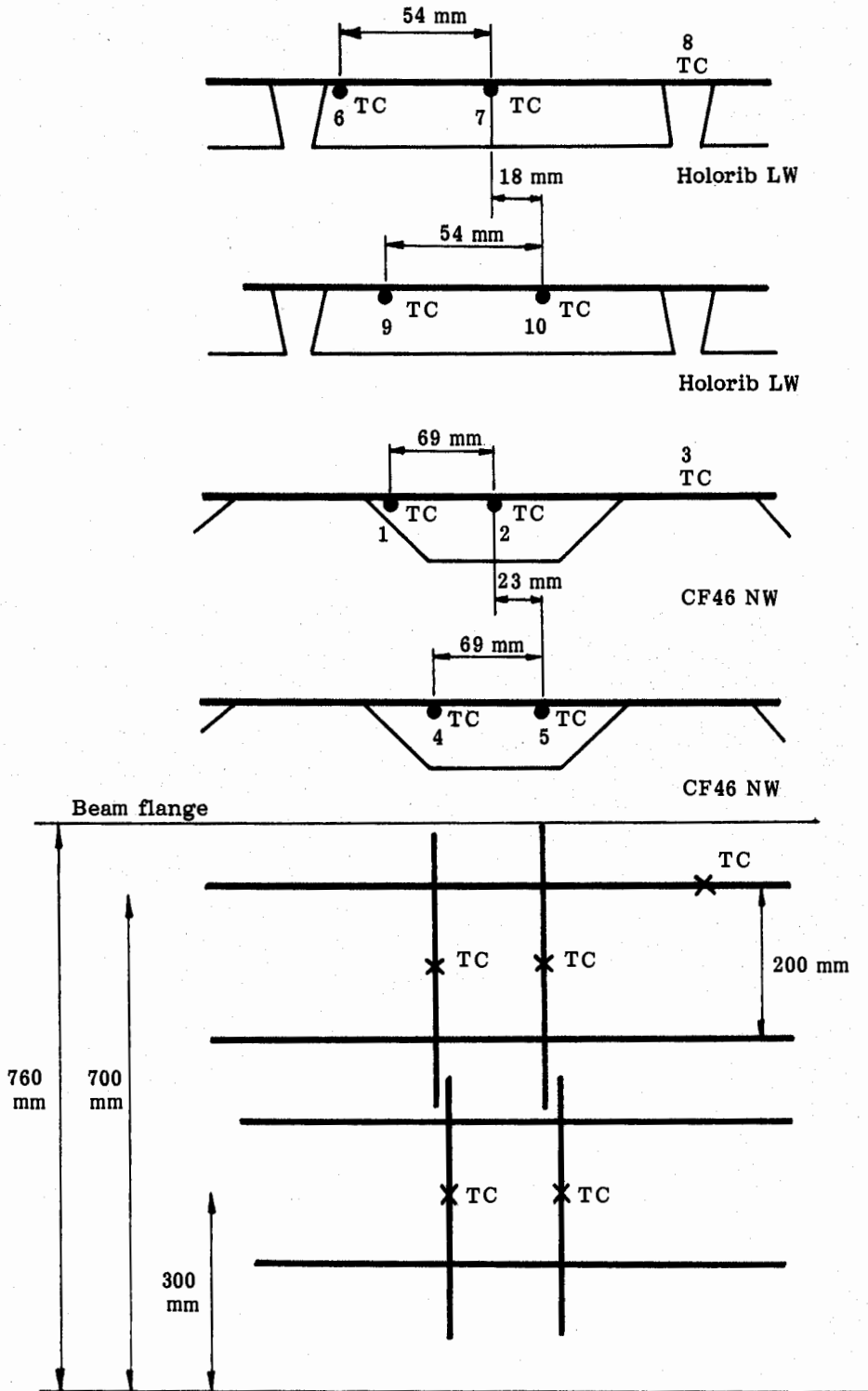


Thermocouple attached to steel deck (a)



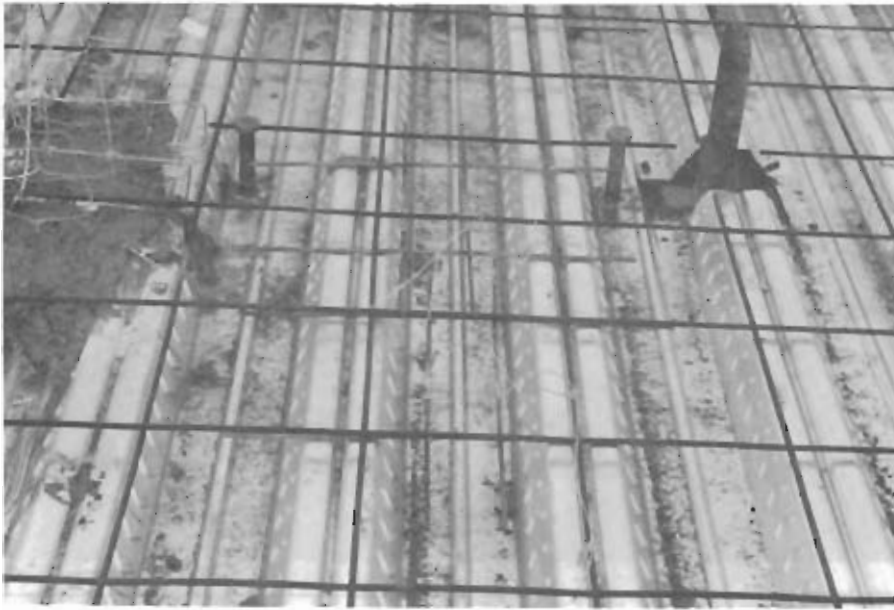
Thermocouples attached to shear studs (b)

FIG. 6



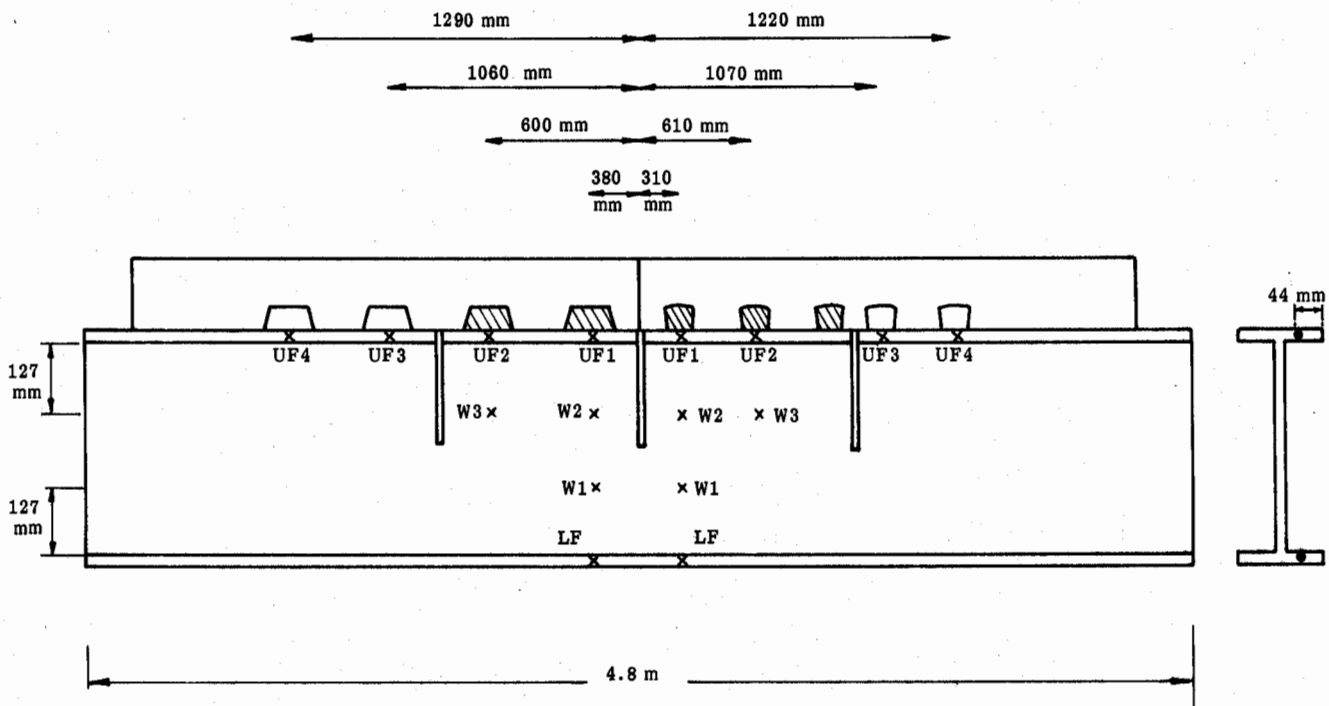
DIMENSIONS AND THERMOCOUPLE POSITIONS OF
ADDITIONAL REINFORCEMENT MESH FABRICATED FROM 5 mm DIA. ROD

FIG. 7
(R2/8959)



POSITION OF ADDITIONAL REINFORCEMENT MESH

FIG. 8



THERMOCOUPLE POSITIONS ON STEEL BEAMS

FIG. 9
(R2/8960)



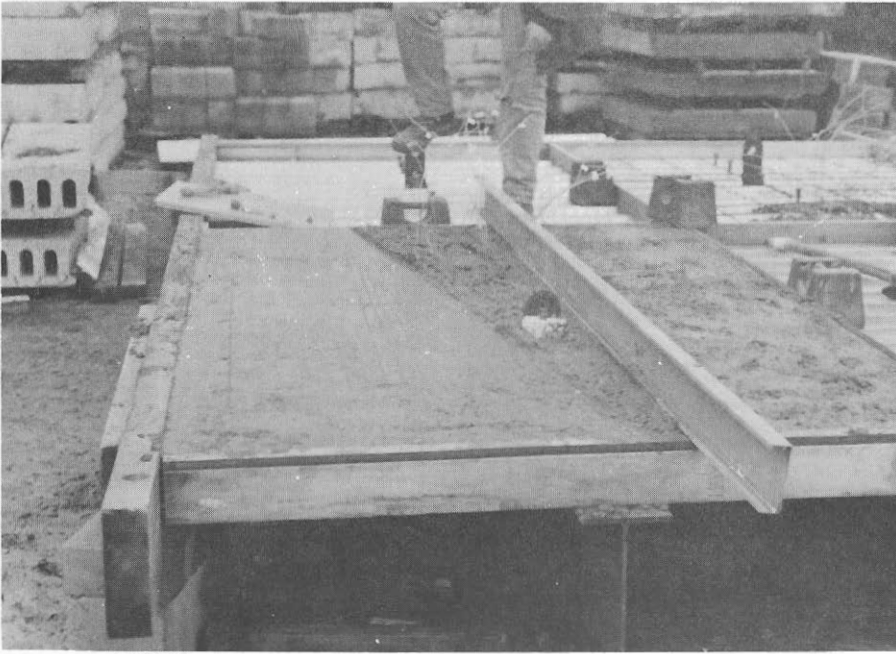
(a)



(b)

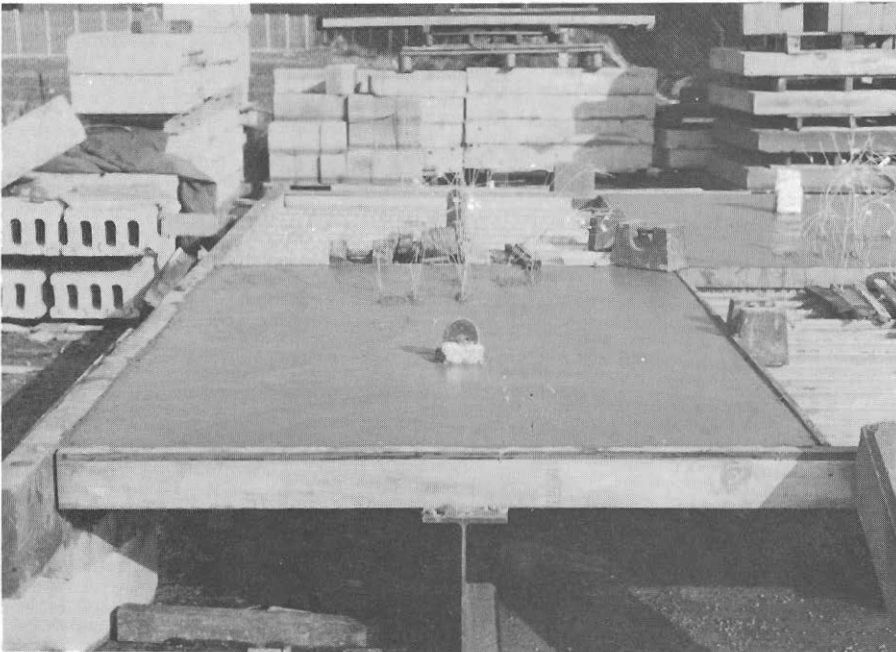
CASTING THE NORMAL DENSITY CONCRETE

FIG. 10
(cont ...)



Levelling the concrete

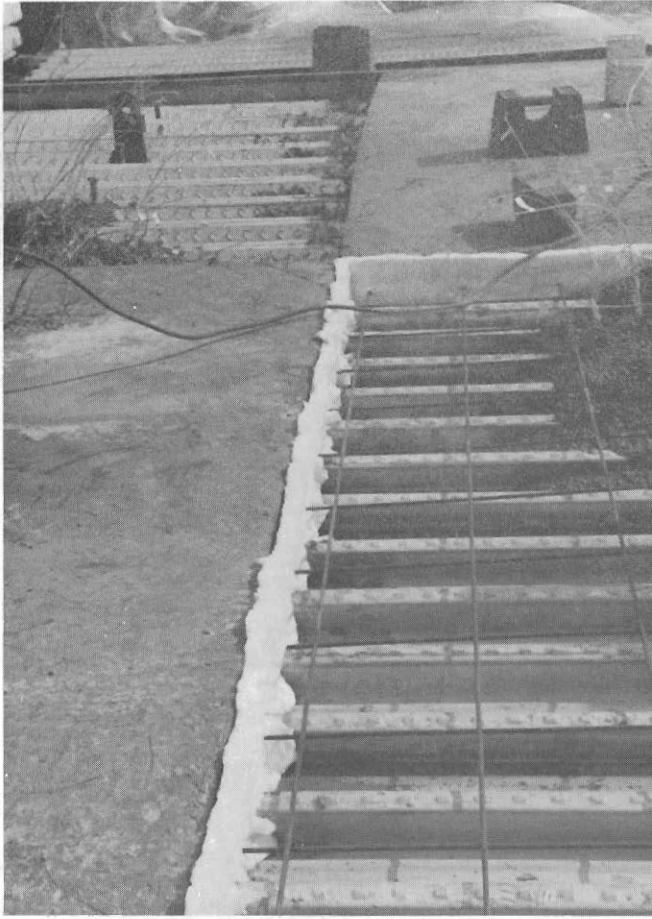
(c)



(d)

CASTING THE NORMAL DENSITY CONCRETE

FIG. 10



Ceramic fibre insulation (a)



(b)



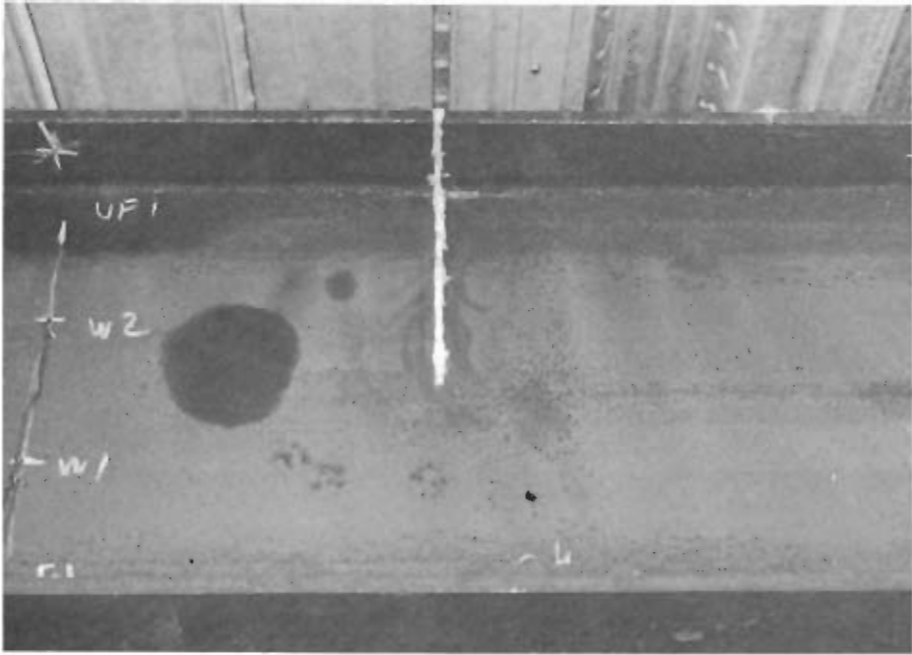
(c)



(d)

CASTING LIGHTWEIGHT CONCRETE

FIG. 11

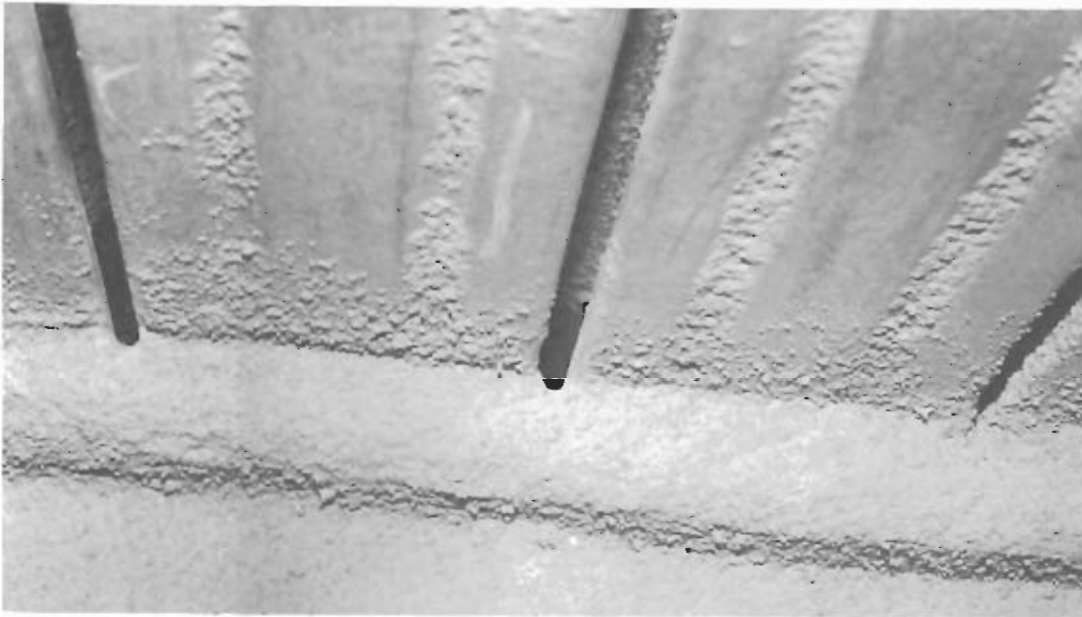


BEAMS PRIOR TO SPRAYING

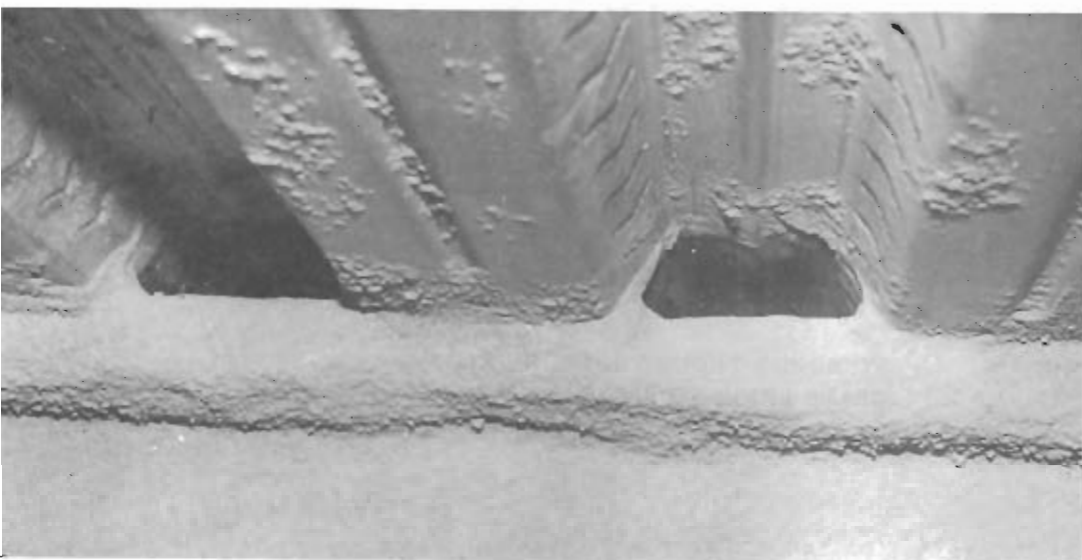
FIG. 12



(a) Beams protected with Mandolite P20



(b) Hollow voids clear of protection



(c) Protection removed from CF46 deck voids

FIG. 13



(a) Transverse hairline cracks

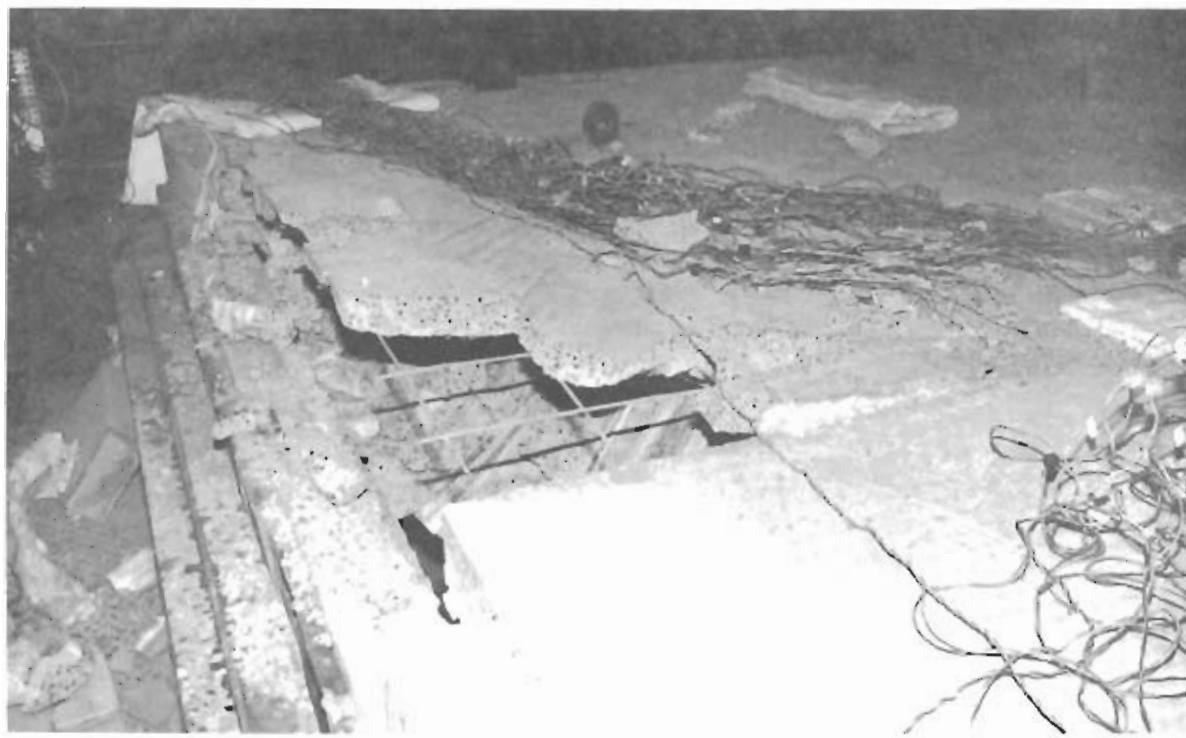


(b) Moisture on light-weight concrete slabs



CF46 DECK DISTORTED AFTER 54 min

FIG. 15



LIGHTWEIGHT CONCRETE ON CF46 DECK AFTER 105 min

FIG. 16