Heave of Bell Canada Building, Ottawa, Due to Expansion of Shale

Eden, W. J.

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TECHNICAL NOTE

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PREPARED BY W. J. Eden CHECKED BY E.P. APPROVED BY C.B.C.

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PREPARED FOR Mr. H.D.L. Morgan, Regional Architect, Bell Telephone Co. of Canada

SUBJECT HEAVE OF BELL CANADA BUILDING, OTTAWA, DUE TO EXPANSION OF SHALE

Bell Canada constructed an addition to their main office building in Ottawa in 1961. The addition extended westward along Albert Street from the original building, situated at the corner of O'Connor and Albert Streets, which was constructed in the 1920's. The foundations for the addition were placed on shale bedrock at the same level as the original building. The extension was completed in 1962 and performed as expected for several years. By April 1967 a heave was apparent in the basement floor slab of the Power Room of the extension. From April 1967 to the present, various surveys and investigations have been made; each showed a continuing rate of heave.

In October 1968 the Division of Building Research of the National Research Council of Canada was asked to undertake work which would explain the movements and possibly lead to measures which would arrest them. In December 1968 surveys were continued by DBR personnel and samples of shale were obtained for mineralogical examination from the excavation for a new building adjacent to the Bell building. These notes summarize the results of the surveys thus far conducted and give the findings to date of the mineralogical examination. Recommendations are made for further work.

HEAVE MEASUREMENTS

Prior to April 1967 the heave made itself evident in that some of the fixtures in the Power Room had to be relevelled. Regular surveys of the elevation of the basement floor had been started in April 1967 and have been conducted periodically since that time. The results of these surveys are presented in Table 1. In November 1967 two holes were cut in the basement floor slab to check on the conditions under the floor. It was found that there was about 4 in. of crushed stone over the shale bedrock. Two rock points, R1 and R22, were installed about 1 ft below the basement floor level to measure the movement in the bedrock. Locations of survey points are shown on Figure 1. This figure also shows contours of heave taken from the last survey, 10 April 1969, based on the assumption that the original elevation of the concrete floor was 96.960 ft. Point 20 shows the greatest rise in elevation, amounting to 0.29 ft or $3\frac{1}{2}$ in.

In Figure 2 the change in elevation of the points along the line from point 2 to point 25 are plotted against time. With the exception of points 2 and 4, these readings, when extrapolated back to elevation 96.960, indicate that the movements seem to have originated in early 1965, three years after the building was completed. This figure also indicates that the heave is occurring at an almost constant rate. Points R1 and No. 1 have stayed at essentially the same elevation with time. Rock point R22 has heaved at about the same rate as point 22 so that the movement seems to be seated at some depth in the shale bedrock.

ROCK ALTERATION

In December 1968 Ron Engineering and Construction Ltd. began excavation for a new building directly south of the Bell building at the corner of O'Connor and Slater Streets. This company kindly allowed access to the site so that the bedrock could be examined in some detail. In December 1968 and January 1969 several visits were made during the rock excavation. The excavation was about 12 ft deep and required from 4 to 5 ft excavation in the shale bedrock. Two extensive zones of altered shale were exposed. Indication of the alteration was in the form of a yellow powder found in the bedding planes of the shale. Closer examination indicated the occurrence of some clear crystals in the bedding planes. Samples were taken to the laboratory for mineralogical identification.

The mineralogical analysis showed that the shale was composed largely of illites, chlorites and some swelling clay mineral. The shale also contained an appreciable quantity of pyrite. The clear crystals found in the altered shale were identified as gypsum. The yellow powder substance was identified as jarosite, a hydrous iron sulphate. Thus the weathering mechanism seems to be that the pyrite in the shale is oxidized to form iron and calcium sulphates and this causes expansion of the shale. The precise conditions leading to this weathering process have not yet been defined.

RECOMMENDATIONS

At present it is known that certain areas of the floor of the Power Room are heaving at an almost constant rate with time. The excavations south of the Bell Canada building revealed zones of shale bedrock that have been altered by the weathering process. The depth of this rock alteration was not determined but it appears to be more than 5 ft. It remains to be proved whether some process of rock alteration is occurring under the Bell building. Thus the following steps are recommended for further study on the Bell Canada building:

1. the periodic surveys of the elevation of the floor slab be continued;

2. a series of rock movement gauges should be installed under the floor slab of the Bell building to try to determine the seat of movement. These gauges should be installed in drilled holes at depths ranging from 1 ft to about 10 or 12 ft. In placing these gauges attempts should be made to recover the best core possible from the drilling. One series of the gauges should be installed in an area in which there has been appreciable heaving and another in an area without heaving;

3. on the assumption that the heaved areas are areas of rock alteration an experimental program should be undertaken on samples of shale to try to define the environmental conditions that permit the rock alteration and subsequent expansion. This program should be supported by the necessary mineralogical studies;

4. if the core recovery from the holes for the rock movement gauges is not successful, it may be necessary to excavate test pits under the floor slab of the Bell building. The object of such test pits would be:

(a) to observe in detail the nature of the rock alteration process

(b) to obtain samples of the rock for experimental studies

(c) to define the depth to which the rock alteration process has proceeded.

Two pits are envisaged, one in an area showing heave and another in an unheaved area. It is hoped that the services of Dr. R.M. Quigley of the University of Western Ontario can be engaged to conduct the detailed examinations in the test pits.

TABLE 1

HEAVE AT SURVEY POINTS

Date	27.4.67		19.6.67		26.7.67		31.8.67		5.10.67		2.11.67		7.12.67		8.2.68		3.4.68		12.6.68		16.12.68		10.4.69	
Point No	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH	Δh	ΔH
1	0	.012	.000	.012	.001	.013	.002	.014	.001	.013	.001	.013	.002	.014	.004	.016	.003	.015	.004	.016	.010	.022	.004	.016
2	-	.054	.001	.055	.002	.056	.003	.057	.004	.058	.002	.056	.003	.057	.006	.060	.005	.059	.007	.061	.017	.071	.009	.063
3	-	.027	.000	.027	.000	.027	.003	.030	.002	.029	.001	.028	.002	.029	.005	.032	.004	.031	-	-	.012	.039	.007	.034
4	-	.049	.001	.050	.001	.050	.004	.053	.004	.053	.003	.052	.004	.053	.007	.056	.005	.054	-	-	.015	.064	.013	.062
5	-	.029	.000	.029	.001	.030	.002	.031	.002	.031	.002	.031	.001	.030	.006	.035	.005	.034	.006	.035	.011	.040	.010	.039
6	-	.026	.000	.026	.001	.027	.002	.028	.002	.028	.002	.028	.002	.028	.006	.032	.005	.031	.007	.033	-	-	.013	.038
7	-	.025	.000	.025	.001	.026	.003	.028	.004	.029	.004	.029	.004	.029	.007	.032	.007	.032	.009	.034	.016	.041	.015	.040
8	-	.005	-.001	.004	.000	.005	.001	.006	.000	.005	-.001	.004	.001	.006	.001	.006	.001	.006	.001	.006	.003	.008	.003	.008
9	-	.007	.000	.007	.000	.007	.001	.008	.001	.008	.001	.008	.000	.007	.004	.011	.003	.010	.004	.011	.006	.013	.005	.012
10	-	.013	.000	.013	.001	.014	.001	.014	.002	.015	.002	.015	.002	.015	.005	.018	.005	.018	.005	.018	.011	.024	.010	.023
11	-	.044	.002	.046	.003	.047	.006	.050	.007	.051	.008	.052	.009	.053	.015	.059	.014	.058	.017	.061	.028	.072	.029	.073
12	-	.005	-.001	.004	.000	.005	.001	.006	.001	.006	.000	.005	.000	.005	.003	.008	.002	.007	.003	.008	.010	.015	.008	.013
13	-	.011	.000	.011	.001	.012	.002	.013	.003	.014	.002	.013	.002	.013	.006	.017	.006	.017	.007	.018	.013	.024	.012	.023
14	-	.023	.000	.023	.001	.024	.003	.026	.003	.026	.003	.026	.003	.026	.007	.030	.006	.029	.008	.031	.012	.035	.012	.035
15	-	.019	.000	.019	.001	.020	.001	.020	.000	.019	.001	.020	.001	.020	.003	.023	.003	.022	.003	.022	.007	.026	.004	.023
16	-	.078	.004	.082	.008	.086	.013	.091	.015	.093	.017	.095	.019	.097	.026	.104	.028	.106	.035	.113	.057	.135	.063	.141
17	-	.026	.000	.026	.000	.026	.002	.028	.001	.027	.001	.027	.000	.026	.002	.028	.001	.027	.002	.028	.004	.030	-	-
18	-	.145	.002	.147	.006	.151	.009	.154	.011	.156	.013	.158	.016	.161	.023	.168	.026	.171	.030	.175	.048	.193	.053	.198
19	-	.133	.007	.140	.013	.146	.020	.153	.025	.158	.029	.162	.033	.166	.043	.176	.048	.181	.060	.193	.093	.226	.104	.237
20	-	.158	.009	.167	.017	.175	.025	.183	.032	.190	.037	.195	.044	.202	.056	.214	.065	.223	.080	.238	.121	.279	.132	.290
21	-	.017	-.001	.016	.000	.017	.001	.018	.001	.018	.000	.017	.001	.018	.002	.019	.002	.019	.001	.018	.004	.021	.004	.021
22	-	.134	.009	.143	.017	.151	.024	.158	.031	.165	.035	.169	.041	.175	.051	.185	.061	.195	.083	.217	.112	.246	.122	.256
23	-	.086	.002	.088	.005	.091	.008	.094	.008	.094	.010	.096	.012	.098	.017	.103	.019	.105	.022	.108	.036	.122	.038	.124
24	-	-	-	-	-	-	-	-	-	-	-	-	.000	.082	.004	.086	.007	.089	.007	.089	.020	.102	.020	.102
25	-	-	-	-	-	-	-	-	-	-	-	-	.000	.019	.003	.022	.003	.022	.005	.024	.013	.032	.014	.033
R-1	-	-	-	-	-	-	-	-	-	-	-	-	.000	-	.002	-	.000	-	-.001	-	.009	-	.001	-
R-22	-	-	-	-	-	-	-	-	-	-	-	-	.000	-	.007	-	.012	-	+.022	-	.053	-	.060	-

Δh - heave in feet from 1st Survey
ΔH - heave in feet by assuming that original floor elevation was 96.960

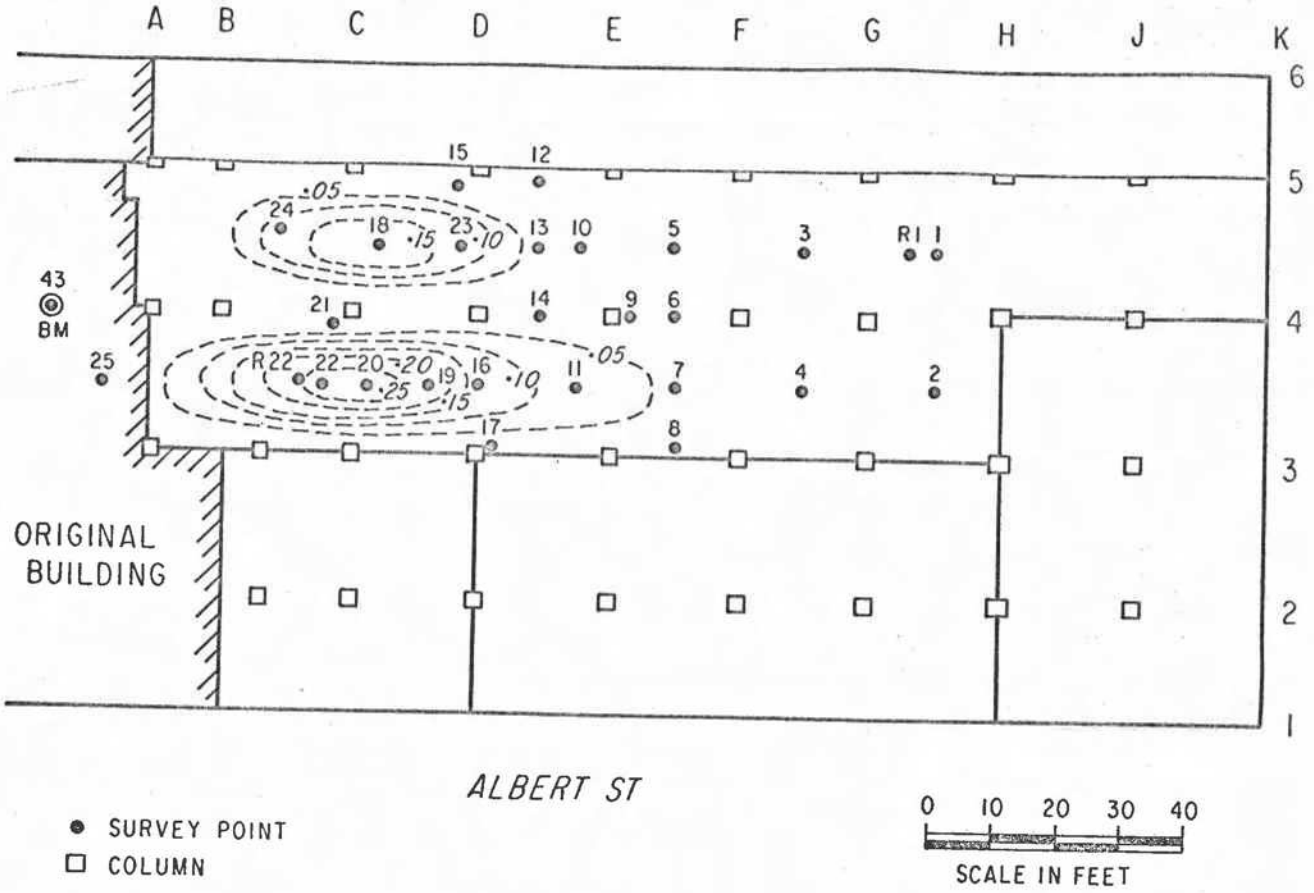

FIGURE 1

PLAN OF EXTENSION TO BELL CANADA BUILDING SHOWING CONTOURS OF HEAVE IN FEET OF BASEMENT FLOOR SLAB

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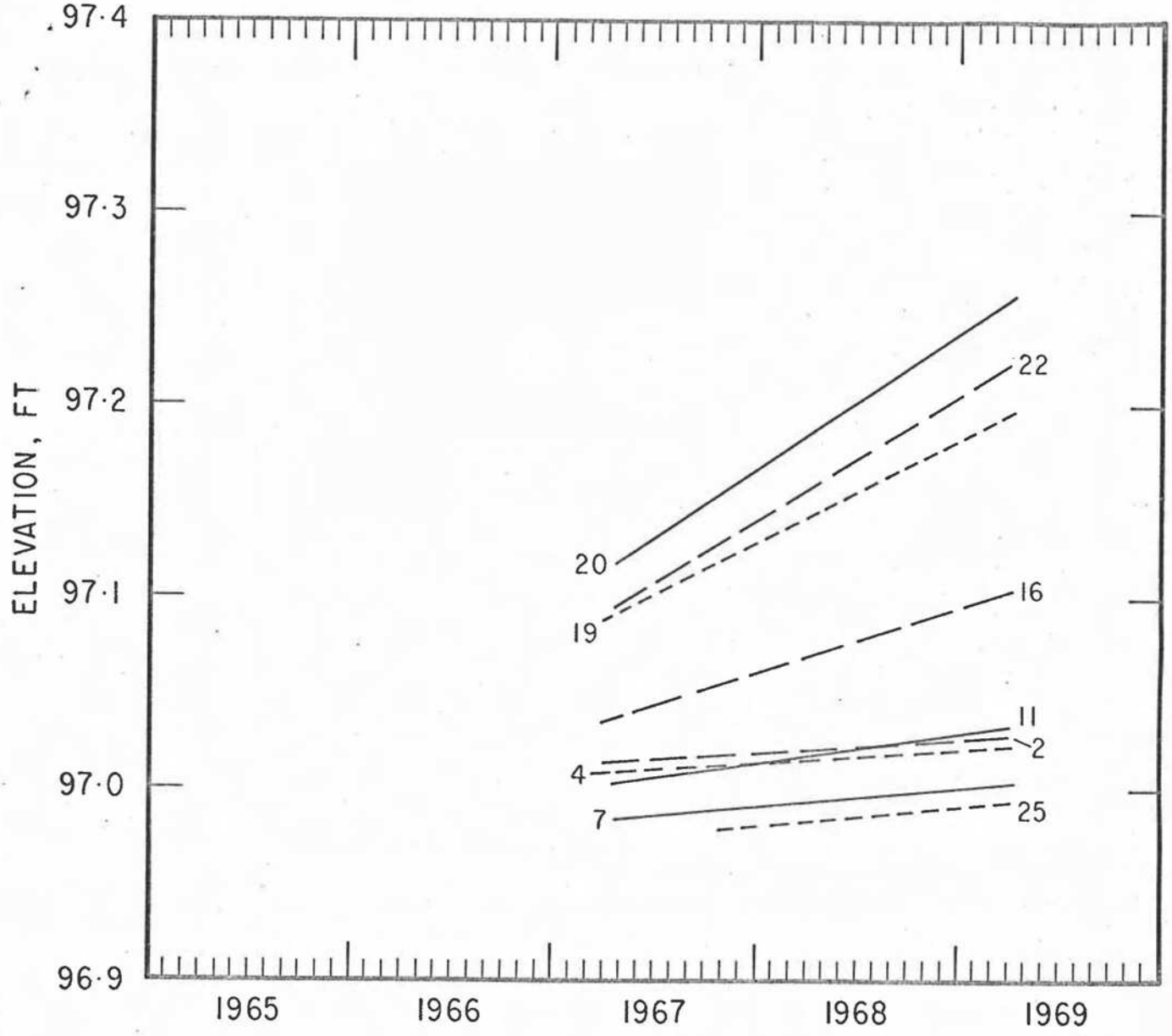

FIGURE 2
HEAVE OF SEVERAL POINTS WITH TIME

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