Donald F. MacDonald in making tests of the rock formation in which the east and west Culebra and Cucaracha slides have occurred. The results of the experiments in brief were as follows:

Twenty-one average samples of the Cucaracha or sliding formation were taken from below the water level of the canal. These samples, completely saturated, contained 12.20 per cent. of water by weight, or 27.8 per cent. of volume. The 16 average samples taken from well above the level of ground water, where the rocks were much jointed and fractured, and, therefore, perfectly drained, contained 10.60 per cent. of water by weight. As shown above, 12.2 per cent. of water by weight fills all of the pore spaces of the rock; therefore, 10.6 per cent. by weight fills only 87 per cent. of them, leaving 13 per cent. of the total pore space as having been emptied by drainage and by drying. Now, 13 per cent. of 27.8 per cent. is 3.6 per cent. of the total volume of the rock. This shows that natural drainage of the most perfect kind would not remove more than 13 per cent. of the water by weight, equivalent to 3.6 per cent. of the volume of the rock. However, most of the samples from the drained rock were taken very close to the surface, so that very likely they lost some of their water through drying out by the heat of the sun, for the dry season was more than a month old at the time they were collected.

These facts show that while the sliding rocks have a high percentage of pore space, the pores are mostly of capillary size and are filled with water, which obeys the laws of capillarity, and which cannot, therefore, be drained off. These experiments definitely established that all cures by drainage which had been offered to and urged on the canal authorities were absolutely futile, and the money which might have been wasted in worthless tunnels, wells, and acres of asphalt covering was saved for the only remedy that could bring permanent cure under the circumstances—dredging.

Before considering the suggestions that have been made for controlling or preventing the slides other than those already mentioned, it may be well to state what was attempted by the canal forces in this direction prior to the occurrence of the slides which are now active.

During the excavation of the Cut 22 slides and breaks of various extent occurred. The steps taken to protect exposed slopes by vegetation have been noted. It was believed that piles driven through the loose material into firm ground below and tied at the tops might check the movement, and this was tried at four of the slides, but without success. In some instances the piles were carried bodily down the slope; in others the underlying material, moving faster than the upper portion, inclined the piles away from the Cut, and in cases where the top surface moved faster than at the bottom, they inclined in the opposite direction. The remains of these piles can be seen at the present time in some of the areas so treated.

It was thought that in case of clay slides heavy riprap dumped on the surface would find its way through the loosened material to firm ground and check the movement, but this method was found as useless as the piling. Most of the riprap rock was taken out at the foot of the slope as the excavation proceeded. Experiments were made by concreting the face of the prism to prevent the disintegrating effect of the air on some of the softer rocks; this was done by use of a cement gun, by plastering the surface with cement mortar and by reinforced concrete, anchored to the side of the prism with pieces of rail. None of these methods was satisfactory or durable. The remnants of the French drains, which proved inadequate, were dug out at the bottom of the prism. The conclusion was reached that the only cure was the removal of all loosened material as it came into the Cut, and in case of breaks to relieve the weight, where possible, from the upper parts of the banks by steam shovels or sluicing operations.

In considering any method for stopping the slides some conception must be had of the enormous amount of material involved, as well as the method in which it acts. The banks at present giving trouble are from 300 ft. to approximately 550 ft. above sea level, and extend back 1,300 to 1,800 ft. from the faces of the prism, and from these farthest points to the water surface the entire mass is broken for a depth extending at least to the bottom of the canal. The movement is by fits and starts, sudden at first and gradually subsiding, with renewed activity after a period of quiescence. For instance, in August, 1916, a general movement occurred at the east Culebra slide and consisted of a settlement from 20 to 25 ft. vertically down at the rear portion of the area affected, some 1,300 ft. from the prism, by which a mass of material from the lower part was projected into the Cut beyond the centre line, reducing the depth of water along this line an average of 5 ft. Because of the width of the new channel, as well as the depth, navigation was not interrupted, but some idea may be had of the enormous amount of material that must be held back by any artificial construction or device similar to those which have been proposed, and the impossibility of their construction must be recognized.

Suggestions most frequently made have been along the line of sowing vegetation and of properly draining the area. These have already been considered. To sink a number of pipes and apply steam for drying out the subsoil would be prohibitive on the score of expense, even if it were practicable. It would be impossible to drive and hold such pipes through the material in case of motion. Pipes sunk for the purpose of pumping out the water are equally impracticable and impossible. From the experiments conducted by Prof. Warren J. Mead and Mr. MacDonald all the water could not be extracted by this method. Piling the entire area at regular intervals and tying the piles to anchors driven in the firm ground can not be done, nor would it secure the result anticipated by the proposers of this scheme.

The construction of retaining walls would require the excavation of material to secure the foundations, necessitating the removal of all the material in motion, when the need for the retaining wall would no longer exist. There is no form of construction that could be designed that would hold back the superimposed mass while the excavation for the foundations was in progress. The construction of inverts to hold down the bottom of the prism is impracticable and impossible.

Wire netting rolled over the bank and held in place by stakes would not prevent the movement, but would seriously interfere with the dredges in removing the material littered up with sections of wire mesh, which would break loose with every movement of the slide. Consolidating the mass by injecting grout would also be impossible; the pipes could not be driven to firm ground below and the earth and rock, as it now comes into the Cut, can be much more easily handled than would be the case were this material solidified by cement.

It was suggested that the slopes and the surface of the ground adjacent to the Cut be covered with asphalt, tar, or some preparation which would exclude water from the ground. This was also proposed by a member of the committee from the National Academy of Sciences. That the committee did not include it among its recommendations seems conclusive that in its opinion it was not practicable, and no further comment seems necessary.

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The Creosoted Block Paving Co., Limited, Toronto, has moved from the Royal Bank Building to more commodious offices in the C.P.R. Building.