BUCKLING OF METALLIC CYLINDRICAL SHELLS UNDER LATERAL LOADING INDUCED BY AN EXTERNAL SOLID MEDIUM

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Many underground shell structures are submitted to a pressure induced or transferred by an external soil medium. This is the case for buried pipelines, steel casing in oil and gas production wells, metallic liner in mine cavity etc... The design of such structures has then to consider the buckling phenomenon. In several cases the practice consists to consider an equivalent fluid pressure. This approach is probably too much conservative.

In this contribution, a test setup has been developed in the laboratory to carry out buckling test on confined cylindrical shells. The external loading can be induced by various types of material confinement as sand or gravel. Then, an extensive experimental study has been conducted to clarify the buckling of confined cylindrical shells submitted to lateral pressure induced by the solid medium radial movement. Several experiments are conducted on thin steel metallic cylinders (Radius to thickness ratio: R/t=150) with sand or gravel as external material ensuring the confinement and the radial loading. In all cases, a significant increase of the bearing capacity of the shells is found. Another consequence of this kind of loading, is the modification of the critical and post-critical behaviour of the shell. Instead of the classical modal mode (characterized by a harmonic) observed generally for buckling under gas pressure, a single inward lobe develops. This explains the enhancement of the buckling load and of the bearing capacity. On the contrary, when the loading was applied through a soft material as EPS (Expanded polystyrene), the buckling pressure doesn't increase.

Numerical analysis is also conducted with Abaqus finite element code, an agreement with experimental results is noticed, confirming that a suitable gain on the bearing capacity can be obtained in the case of a confined shell.

Finally, the conducted experimental and numerical campaign allows us to gauge the difference between the cylindrical shells buckling and post-buckling behaviours, in the case of lateral pressure induced by an external solid medium, and in the case of fluid lateral pressure. Recommendations are proposed for a less conservative design method suitable to the configuration of buried cylindrical shells structures.

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