Rammed Earth Beams
Project Overview

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Introduction

Rammed earth is an ancient construction technique. Earth is taken from the surroundings, sieved, and mixed with a small amount of water. A thick layer of the earth mixture is placed within a temporary formwork, generally made from wooden planks. The earth is compacted by ramming it with a heavy handheld tool. Once a layer cannot be compacted any further, more earth is poured on top and rammed in place (Figure 1). This technique can be used to make strong, thick walls that can last centuries.

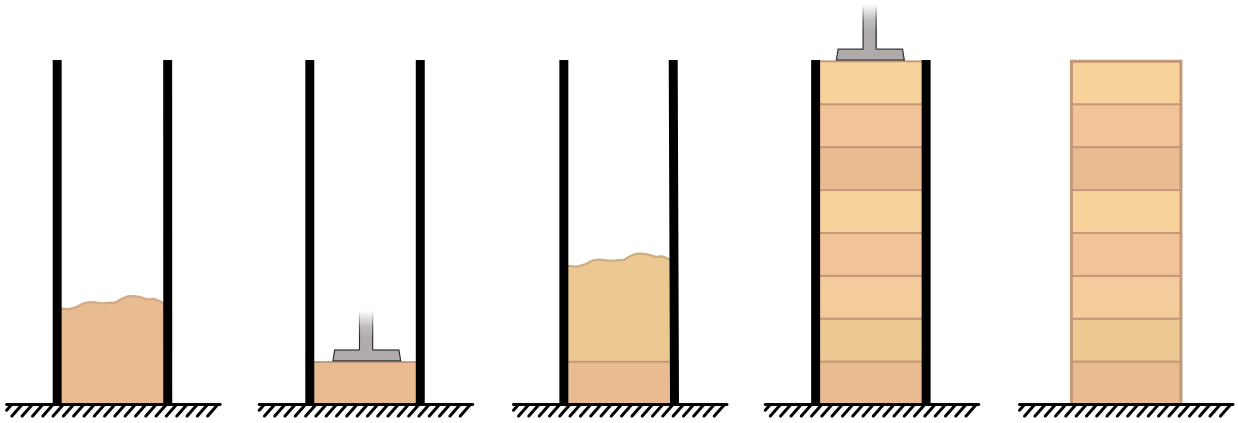

Figure 1: The construction of a rammed earth wall

Rammed earth is often considered a sustainable material as it has a low embodied carbon - meaning the processes used to make it emit very little carbon dioxide. Materials can be taken from the site or nearby and then sifted, mixed, and rammed by hand. If desired rammed earth can be ground up, mixed with a small amount of water and rammed into a new wall.

Rammed earth could be considered similar to concrete - a material with a very high embodied carbon. The key ingredient in concrete is cement. Cement is made by heating calcium carbonate (found in limestone) to produce calcium oxide and carbon dioxide through thermal decomposition. The CO_2 released by burning the fossil fuels required to heat the limestone and the CO_2 released during this reaction can have a significant impact. Some sources estimate that 5% of global carbon emissions arise from the production of cement. There are many ways to reduce the embodied carbon of concrete, but it is likely that concrete production will need to be stopped entirely in order to achieve net-zero. In certain cases, rammed earth could be used as an alternative material.

Both rammed earth and concrete are aggregate materials, meaning they are made up of many small small strong particles (sand and gravel) held together by a binding agent (clay for rammed earth and cement for concrete). They are very strong in compression as they can rely on the high compressive strength of the aggregate particles. They are much weaker in tension as the binding agent tends to be less strong than the particles. To compensate for the lack of strength in tension, steel reinforcement is often added to concrete. This project aimed to determine how well steel reinforcement could be used in rammed earth and whether it is possible to make reinforced beams from rammed earth.

Experiment

Three large beams were created in a manner similar to reinforced concrete beams. Each beam measured 1200 mm × 250 mm × 150 mm and was reinforced with two bars of 6 mm diameter steel. The ends of the rebar were bent at 90° to improve their anchorage.

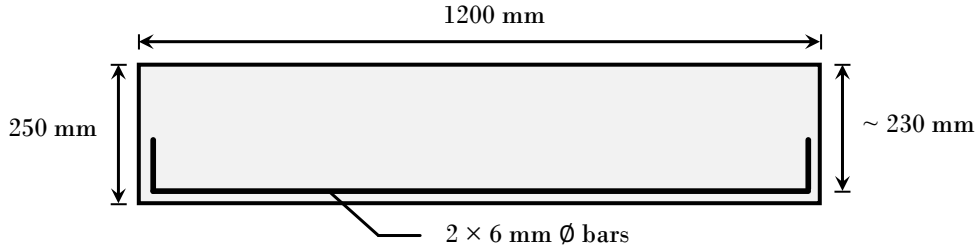

Figure 2: Dimensions and reinforcement layout of rammed earth beams

The beams were subjected to what is known as three-point bending. The beams were rested on two roller supports - one at either end. The beams had a load applied to their centre with a large hydraulic press.

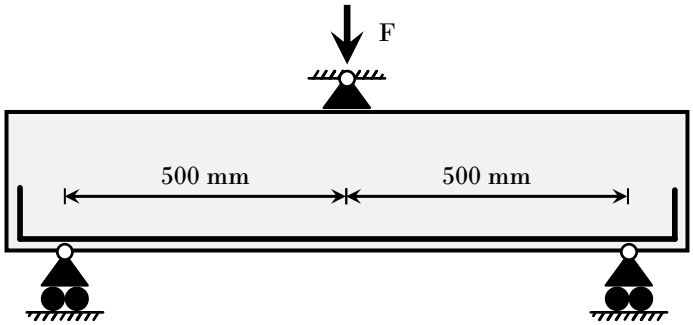

Figure 3: Three-point bending

The load applied to the beams was increased until they failed. The broken beams were taken out of the test rig and cylindrical samples were cut from them using a core drilling machine (Figure 4). The cylindrical samples were then tested in compression using another hydraulic pressing machine to find the compressive strength of the material in the beam (Figure 5).

Figure 4: Core drilling machine

Figure 5: Compression tests of core samples

Conclusions

Buildings are designed to meet certain standards, known as design codes. They are usually specific to the region in which they are built. The codes provide calculations that can be used to prove that the structure has been designed to have an adequate strength. The calculations for the strength of concrete beams involves the compressive strength of the concrete and the area of the steel bars in the beam. These calculations were performed using the compressive strengths found from the cylindrical core samples in order to estimate the strength of the rammed earth beams. Unfortunately, the beams failed at a load that was lower than what was predicted by these calculations. Hence, the design codes for reinforced concrete beams were shown not to be applicable for beams made from rammed earth and reinforced with steel bars.