Application of Different Materials in Construction of Bridges

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In this report, the applications of different materials used to build bridges with different requirements have been discussed using the mobile phone application called "Bridge Construction". At each stage of this game a certain number of different materials have been provided with a limited budget and the objective is to design a bridge with the least amount of materials that is able to carry the loads of 2 trucks passing over it.

Starting with the simplest example, a bridge must be designed on a road with a 20m gap over the river – Figure 1. In this stage only wooden members and spans have been provided. In order to avoid the fall out of the bridge, a truss has to be designed over (or under) the beam span/beam deck (the bridge is at the verge of failure on its own without the truss – Fig 2). This truss pushes the deck of the bridge together. Otherwise the bridge would fail (Figure 3 shows the stress in the bridge when it is not appropriately supported). The role of the truss is to transmit the downward loads exerted by the vehicles to the supports and it prevents bending and subsequently collapse of the bridge.

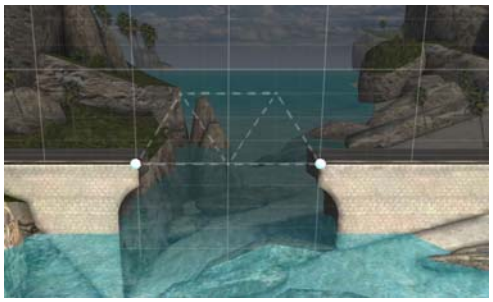
Figure 1

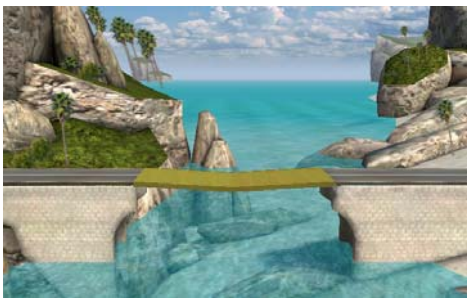
Figure 2

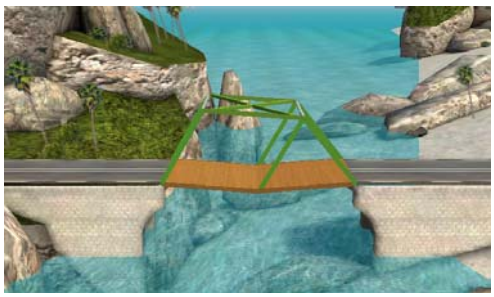
Figure 3

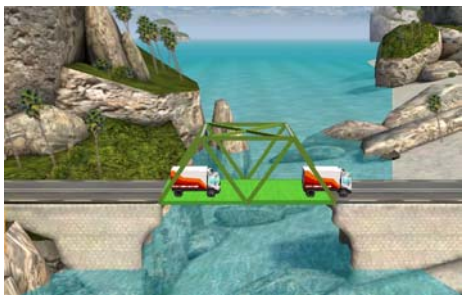
Figure 4

Why do they use wires in the bridges?

Now that the concept of this game has been clearly introduced, we move on to a more complicated situation where a **longer** bridge is required. For the construction of this 80m bridge concrete columns have been provided along with wires. The wires can be applied on the members under great deal of tension and also they can be designed in larger lengths as there would not be any buckling problems in tensile members.

So in this stage, after fitting the wooden span of the bridge, two long concrete columns will be placed at the two ends of the bridge and four wires will join the base to each column as it can be seen in Figure 6. When the base is under the compressive stress generated by the vehicles, the wires will be subjected to tensile stress that will be transmitted to the concrete columns and then to the ground. The columns themselves will be under compression and as the concrete is very strong under compression, the structure will be fine.

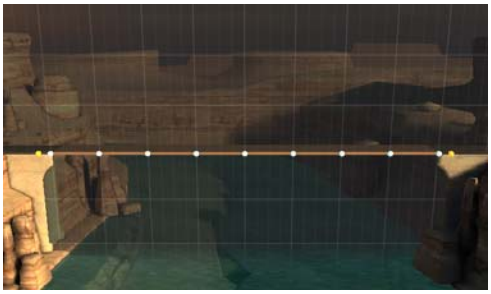
Figure 5

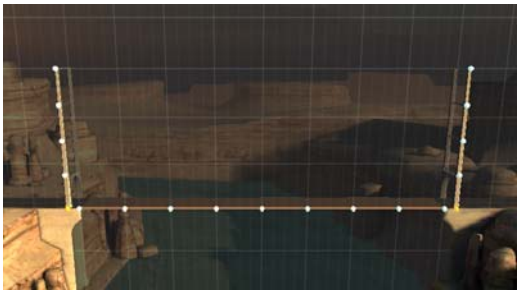
Figure 6

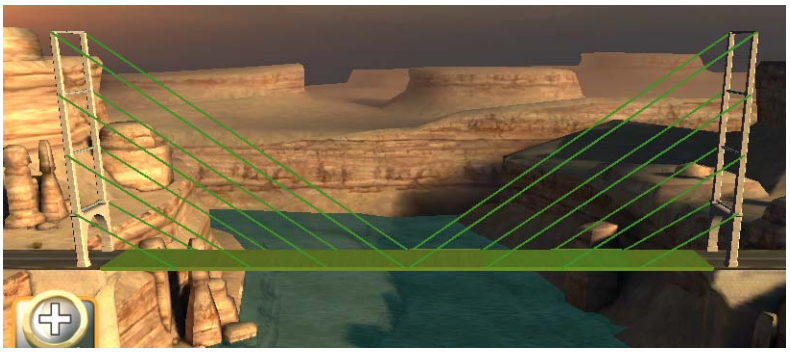
Figure 7

Why using steel members in the structure of the bridge?

Another material that can be used in the construction of buildings is steel. Steel is greatly stronger than wooden members and it is functional in both tensile and compressive conditions. Hence, it is a good replacement for the wooden members in the trusses that are under too much stress.

The next task is to design a bridge over a 60m wide river and wood, steel and wires are available. As this is a quite long distance and we cannot use concrete columns, we have to design a truss but this will not be sufficient and we need to support this truss by a few members to a point farther than the end point of the bridge (otherwise the bridge bends and fails by its self-weight – Figure 8).

Now we change the design by shifting the truss to the bottom of the bridge (Deck truss rather than a pony truss) and placing two supports at each end of it, which would be wired to the ground – Figure 9. The results show that some of the members are under too much stress and the bridge fails. Now the weak points of structure can be identified (red members are carrying great amount of stress whilst green members are just fine) and they can be replaced with steel materials. The main necessity is to change the vertical members at two supports and the horizontal ones at the bottom (under the water) – figure 10, but ideally some of the inclined members could have been changed to steel (figure 11) but the bridge was strong enough for the nominated design loads.

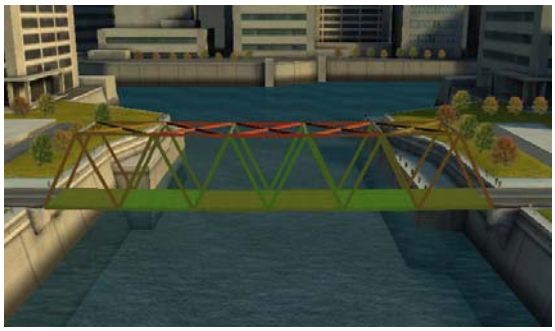

Figure 8

Figure 9

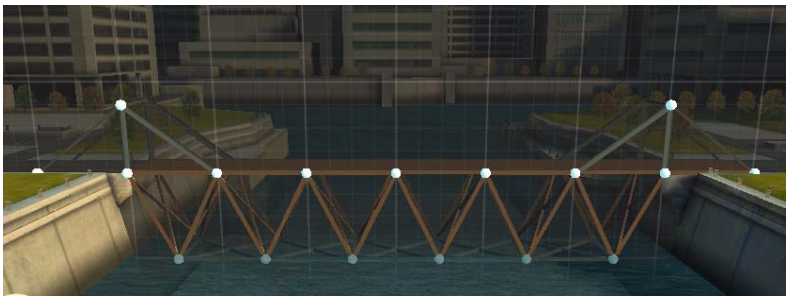

Figure 10

Figure 11

In a nutshell, in designing a bridge, one of the most crucial aspects is the length of the span. Depending on the length, we can determine whether the bridge should be a truss bridge, suspension bridge, cantilever bridge, arch bridge or a simple beam bridge. If we are designing a small bridge, it can be a truss bridge but for longer distances, this truss must be somehow supported to the ground to prevent bending or we perhaps may need to consider suspension or arch designs. Also in terms of materials, similar to the concept of this game, the cost should be minimised and for instance, the wires do a great job in tensile members whilst being considerably cheaper and steel must be used where other materials cannot endure the amount of applied compressive loads to the member. Concrete is also a very strong material, which may be placed where a large amount of compressive force has to be transmitted to the earth.

References

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