Mystery of Shaking Minarets

A Research Paper

By

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Abstract: Shaking minarets (also called "Jhulta Minar") are located in the city of Ahmedabad, Gujarat, India. They are so built that one can shake them by giving a gentle push on their upper part. Minarets are almost three stories high. They have been constructed completely using sand stone - a very rigid material. No steel or any other flexible materials are used. Even then, minarets are so flexible that they can be shook easily. I did my research to find reason behind their flexibility and thereby, give my theory on it.

Keywords: **Shaking Minarets, Jhulta Minar, Flexibility .**

1. Introduction

Shaking Minarets are a part of Sidi Bashir mosque. Sidi Bashir, a slave of Sultan Ahmed Shah, built it. These minarets are almost three stories high. The construction of Minarets was completed in 1452. Due to its movement (shaking), they are called Shaking Minarets or Jhulta Minar. Another mosque in Ahmedabad city, Raj-Bibi mosque also has similar type of minarets. The Minarets were built in ancient time by topmost skilled and talented craftsmen of the Mughal empire. Unfortunately, the British people dismantled one part of those minarets to study the structure and they never put it back together.

Currently, they are sealed by the Archaeological department of India. One can visit it by taking special permission only.

2. What is the mystery?

The speciality of the minarets is that they can be shook from back to front. If one gives a gentle push to the topmost arches of the minarets, then the Minar can be seen swaying from back to front. By observation, we can see that windows have been provided in east-west direction. Whole minarets are hollow. There is a provision of circular stairs to provide access to the upper side. As it is shown in photograph #5 (In appendix), these minarets are completely constructed from sand stone, which is one of the most brittle materials. So theoretically, a sand stone is so rigid that application of slight tension is enough to break it. Further, these shaking minarets are almost 550 years old. During this time, there have been many demonstrations of its extraordinary flexibility. From structural point of view, steel is provided in structures for flexibility. However, in shaking minarets, there hasn't been any use of steel or any other flexible material. Further, they are 550 years old and till now there is no appearance of even a single crack due to tension in sand stone.

Then why are these minarets so flexible as a gentle push can shake it? Is there any special type of stone or other material that is used in its construction? Or is there any special type of construction technique that is used? Alternatively, any other reason.

I carried out research work to find an answer to this question and came up with my theory for it.

3. Solution from logical point of view:

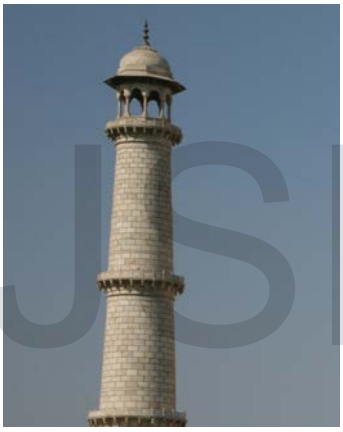
Reason behind this mystery is very simple but interesting. There has been usage of the very basics of "Solid mechanics".

For explanation, first we learn what is the basic difference between other minarets and shaking minarets. Generally, grooves are avoided in all minarets, which means any setbacks are not provided. Mostly, surface of minarets are kept plain or vertical grooves are provided on the surface. Grooves are provided only for architectural aspects.

The following two pictures gives example of minarets with no grooves.

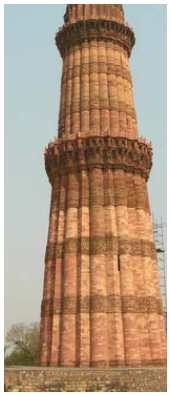
1. Chapaner mosque minarets, Vadodara. (Plain surface minarets)

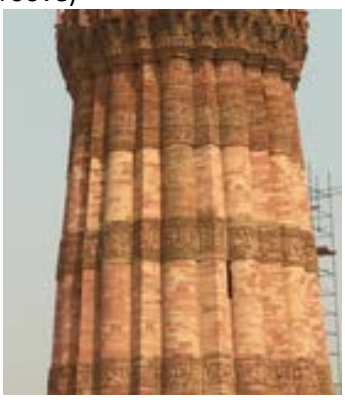
2. Taj mahal minarets, Agra (plain Surface Minarets)



The following picture gives example of minarets with vertical grooves.

3. Kutub Minar (vertical groove)





In contrast to other minarets, shaking minarets have horizontal grooves, as shown in the picture below. It is strange but it is the logical reason behind its flexibility.

These types of horizontal grooves are provided only in shaking minarets. This is the main logical reason to why shaking minarets are so flexible as compared to the other minarets of the same size. Solution from technical point of view
will be shown in the next section.

Photograph of Shaking minarets, Ahmedabad

4. Solution from Technical point of view.

As we know, flexibility is deflection per unit load. Deflection mainly depends on its rigidity or stiffness. The higher the rigidity, the lower the deflection. Now rigidity depends on Moment of Inertia.

Consider Minarets as a Cantilever vertical beam. We take cases of two different cantilever beams - first with constant cross section as in general minarets and second one containing setbacks (grooves) as in shaking minarets. Now we draw bending moment (B.M.) diagram and M/EI diagram for both the cases.

Deflection is equal to Moment of M/EI diagram about support. So from diagram it is clear that M/EI diagram of Shaking minarets has more area as compared to equivalent Plain surface minarets and as area of M/EI diagram is more, moment is also more and with that deflection for same load is also more.
So, this is the mystery behind flexibility of Shaking Minarets. By using this logic, shaking minarets were constructed.

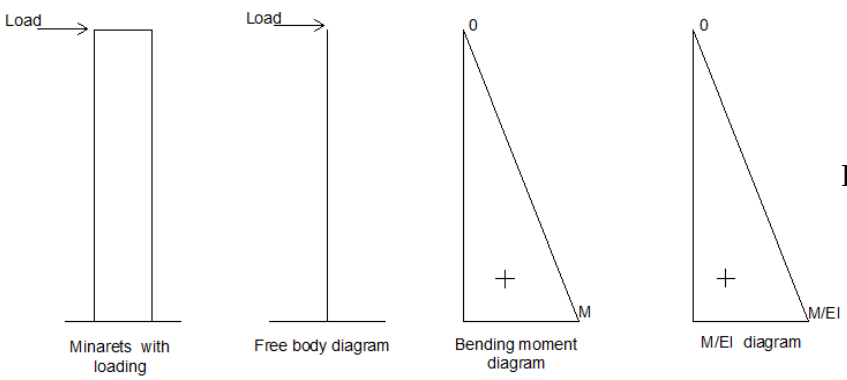


Diagram for General Minarets

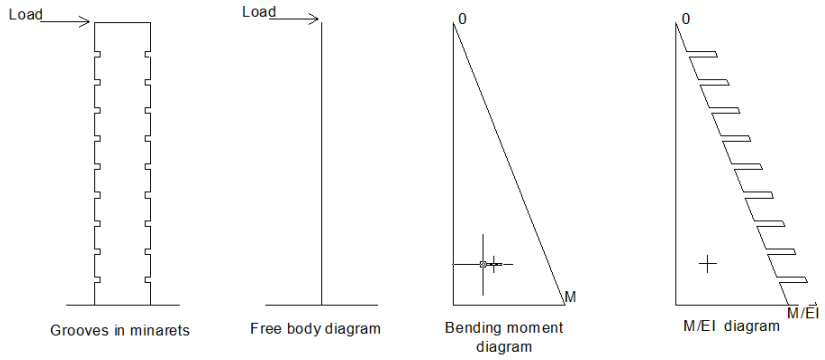


Diagram for Shaking minarets

5. Where this concept is used ?

From this we can see that one can increase flexibility of a rigid material by changing only in design or paten. So by use of this concept we can also make concrete more flexible by keeping same amount of reinforcement. Not only concrete but any other rigid material.

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Photograph: Shaking minarets ,Ahmedabad India

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