RESILIENT STRUCTURES

G.Arul, Tamil Nadu Science Forum (TNSF), 6, Kakkathoppu Street, Maduurai-625001

Episode-49

Disaster resilient structures (Urban & Rural

Science of good practices with local examples

Examples from Japan, Hong Kong and other earthquake prone States.

Mr. Suman - Father - Businessman

Mrs.Preethi - Mother

Ms.Nithi - Daughter - Student

Dr. Kishore - Architect (family friend)

Roshan - Nithi's friend

Rep - at the builders' expo

Scene 1

(Mr Suman's family is visiting a building expo. They are planning to construct a new house)

(On a Sunday evening)

Suman: (to wife) Hi dear, I saw an advertisement in today's paper about an expo organized by the builder's association.

Nithi: Yes dad. I read it in the newspaper too. It is a builder's expo which is open to the public till next week.

Preethi: It is timely news, darling. Shall we all visit the expo this evening? Are you interested, Mr.Suman?

Suman: Yeah! I am much interested to visit it. See...We have already had plan to construct a bungalow of our own. So we shall go this evening. Get ready, everyone.

Nithi: Hurrah! Jolly! Mummy, will there be a merry go round? Will you allow me to have a ride in the giant wheel. If you permit, I will invite my friend Roshan too.

Preethi: Our family friend Mr Kishore will be happy to join us. Shall I invite them?

Suman: Invite them and make sure they are at the exhibition venue around 4:00 pm.

Preethi: Okay then, I shall prepare some tea now for everyone

. (Everyone gets ready to visit the expo)

Scene 2

(Expo - "GREEN BUILDING" - number of stalls have been put up by builders and fanfare activities go on)

(The expo committee makes a public announcement and invites people go visit the different stalls)

Nithi: We have reached the expo. I hear the music and I can see the crowded venue.

Suman: You are right, Nithi, we have reached the place. We will get down from the car.

Roshan: Uncle. All of you wait here. I will purchase the entry tickets and come.

Preethi: See... Roshan has become very responsible after joining his engineering course.

Nithi: ad! See! The giant balloon at the entrance. Wow! Colorful and beautiful. It is also written as "GREEN BUILDING." Do they mean the colour of the building, Dad?

Suman: I see my little girl is very excited to visit the exhibition. We shall now enter into the expo. Roshan, are you ready with tickets?

Roshan: Yes, uncle, we shall go.

Preethi: Oh look there. Mrs and Mr Kishore are already waiting for us. Hello Kishore, how are you?

Kishore: Hello. We are fine, thank you for inviting us. Come, let us go and visit the stalls one by one then.

Suman: We shall enter into this stall titled "GREEN BUILDING" first.

Rep: Please come in, sir. This stall exhibits the products related to construction, which are environment friendly. Such building materials reduce the use of energy. These buildings are called green buildings. They have natural lighting. They have a natural cooling system which minimizes the use of electrical energy, sir.

Suman: Thank you for your valuable points, I hope my daughter's question on green buildings is answered now.

Preethi: We shall move to the next stall. It is something different from the other stalls. The title is also different: "Future Building." Let's have a look.

Rep: Please come in, sir, you have entered the 'Future Buildings' stall. This stall exhibits the building structures to be constructed in the future.

Roshan: Future buildings, hmm... That sounds interesting. What do you mean by the word 'future'?

Rep: Sir, today's world and its people are facing many natural calamities and disasters. This stall will explain the various structures like houses, malls, shopping arcades, stadiums, bridges and various buildings which are prone to disaster.

Kishore: Oh yes, I understand now. You mean to say resilient structures. It is quite interesting to visit this stall. We would like to see the designs.

Nithi: I don't understand your conversation. You were talking about 'resilient structures.' What is it? Please explain it to me, Uncle.

Kishore: Hey, Nithi, come to my house tomorrow. I shall explain it with some reference Materials.

Suman: Nithi, see... We have reached the entertainment section. Go with Roshan for a ride in the giant wheel. Are you ready?

Roshan: Ready, Uncle. I have already purchased tickets for this ride too. Come on, Nithi.

Kishore: Let's relax here till they finish the ride. Why don't you order some snacks? I'm hungry already Mrs Suman.

Preethi: Sure, I will get you some snacks now.

Suman: It's time and we have already visited a good number of stalls. Some are interesting and many are informative. Come let's go back to our homes.

Scene III

(Dr Kishore's gallery – Mr.Suman, Nithi and Roshan are waiting in the hall to meet Mr Kishore)

Suman: Dear Kishore, I have brought my children to interact with you on resilient structures to withstand disasters.

Kishore: Fine. Hello, Nithi and Roshan. How are you doing today, my dear young friends! Come, let's go and sit inside my room. Then I'll show take you to the gallery where you can see the evolution of shelter and other structures from the past.

Nithi: Sure, Uncle. Will you begin by explaining to me the meaning of resilient structures?

Kishore: Sure, Nithi. Throughout human existence, homes have varied drastically in scope, size and design. Cob houses originated in the eleventh century;

they were made of straw and earth and lasted for hundreds of years. We've come a long way from our cave dwelling ancestors

.

Nithi: That's quite interesting, Uncle. Please take us to the gallery.

Kishore: Yes dear. This gallery is about the evolution of shelters from the past. You may even notice future structures and those that can even withstand natural disasters.

Roshan: Uncle, please explain the earlier structures used by human beings.

Kishore: The first poster shows you a 'mammoth bone dwelling.' These are very early type of house constructed by palaeolithic hunter gatherers mammoth was a type of enormous, ancient, now-extinct elephant. It stood ten feet tall as an adult. A mammoth bone dwelling is typically a circular or oval structure with walls made of stacked large mammoth bones.

Nithi: Wow, interesting. What is this in the next poster, Uncle?

Kishore: This is a 'hide tent.' All prehistoric humans used animal hide for clothing and shelter. The Intuits, for example, used animal hide to make summer tents, waterproof clothes and kayaks. Various American Indian tribes used hide in the construction of tepees, wigwams, moccasins and buckskins. Rabbit and squirrel skins were traded and taxed in timbers of 40 hides each. The parchment and vellum were traded based on dozens of the original sheepskins from which they were prepared.

Roshan: Even today, we use animal skins to make various products ranging from purses to book covers.

Kishore: Yes, Roshan. The next poster is about 'mud bricks.' It is made of a mixture of loam, mud, sand and water along with binding material such as rice

husks or straw. In warm countries with very little timber available to fuel a kiln, bricks were generally sun dried.

Nithi: Uncle, I have seen a brick factory near my grandma's village. What is this next poster about?

Kishore: The next poster is on 'stilt houses.' These are houses raised on tall wooden logs called stilts over the surface of the soil or a body of water. These structures are built primarily as a protection against flooding. Such structures which can withstand natural calamities are termed as sustainable structures or resilient structures.

Roshan: We would like to know more about these structures, Uncle.

Kishore: That's nice, Roshan! The next poster is on a type of structure called 'domus.' These were houses occupied by the upper class and some wealthy men in ancient Rome. Domus comes from the word domesticus, from which we also get domestic.

Nithi: Hmm... The next one resembles today's apartment type buildings, Uncle. But they look like ancient structures. What are they?

Kishore: These are called 'insula.' It is a kind of apartment building of ancient Rome. The ground level floor of the insula was used as a shop or for a business, while the living space was upstairs.

Roshan: Uncle, the next one seems to be 'timber framed structures.' Which era do these belong to?

Kishore: This 'timber framed structures' belong to the 1st century. Traditional timber framing is the method of creating structures using heavy squared-

off wooden bogs. There are three basic types of timber frames. These are the box frame, the crux frame and the aisled frame.

Nithi: I've noticed some old churches with curved timber frames in our very city too, Uncle! They're amazing. Let's move on to the next one now.

Kishore: This structure is called a 'mudhif.' A 'mudhif is a large communal house, paid for and maintained by a local sheik for one by guests or as a gathering place for weddings, funerals etc. These are constructed with bundled and woven reeds. In the same way, in Japan, people constructed the 'machiya.' It is used by urban merchants and craftsmen.

Roshan: Intriguing, Uncle. Could you explain the next one?

Kishore: The next poster shows a 'cob' or a 'clom.' It is a natural building material made from subsoil, water, straw and lime. Cob is fireproof and resistant to seismic activity. This has been revived in recent years by the natural building and sustainability movements.

Nithi: Uncle, the next one looks like a circus tent. Will you please explain it?

Kishore: This structure is called a 'yurt.' It is a portable round tent covered with skins or felt and is used by nomads. These structures are made with an assembly of bamboo sticks.

Roshan: The next one is a 'Gothic structure.' Am I correct, Uncle? I have seen this beautiful structure in my school campus. The beautiful St Xavier's Church in Goa is an example of Gothic architecture too!

Kishore: Well said, Roshan! These originated in the 12th century in France and lasted into the 16th century. Gothic architecture is most familiar to us as the architecture of many of the great cathedrals, abbeys and churches.

Nithi: Uncle, the next one is a very common sight in our country. What are they?

Kishore: These are called 'Victorian houses.' These structures evolved in the 19th century during the reign of Queen Victoria. They were followed by modern 'pre-fab homes.' These are special dwelling structures, usually in standard section that can be easily shipped and assembled.

Roshan: Hmm... Uncle, these domes look very attractive. Will you explain?

Kishore: These structures are called 'geodesic domes.' It is a hemispherical thin-shell structure. The geodesics intersect to form triangular elements which have local triangular rigidity. Based on this idea, the EPS Personal Dome is constructed. This structure is made of Styrofoam. It is impervious to natural disasters, hurricanes and earthquakes and the shape is naturally wind resistant. These structures are eco-friendly, energy-efficient and easy to construct. There are already being used in disaster relief efforts across the globe. Such structures are termed as resilient structures.

Nithi: What is meant by resilient structures?

Kishore: The resilient house provides an interactive guide to climate change adaptation of the house, with regards to the problems that may arise from extreme weather events.

Roshan: Will these be our future structures, Uncle?

Dr.Kishore: In all likelihood, the future will bring more intensive rainfall or strong heat waves and drought. Cloud bursts and sudden thawing typically affect home owners and the basements of houses. Most severely, as large quantities of water pool up near houses. These 'interactive houses' offer advice on how to protect your house against climate change.

Nithi: So resilient structures can withstand disasters…

Kishore: Yes. We are today facing natural disasters like Earthquake and Tsunami, Hurricanes and Cyclones, Heavy floods, which are becoming more adverse due to
unsustainable development models.

Nithi: Do you have any home to with stand Earthquake?

Kishore: An Earthquake moves the ground. It can be one sudden movement, but more often it is a series of shock waves at short intervals, like our ripples from the pebble in the pond analogy above. It can move the land up and down, and it can move it from side to side. All buildings can carry their own weight. They can usually carry floor loads and suspended loads as well, vertically; so even badly built buildings and structures can resist some up-and-down loads. But buildings and structures are not necessarily resistant to side-to-side loads. This weakness would only be found out when the Earthquake strikes, and this is a bad time to find out. It is this side-to-side load which causes the worst damage, often collapsing poor buildings on the first shake.

Roshan: If so uncle, what would be the resilient structures to withstand EQ.

Dr.Kishore: To be earthquake proof, buildings, structures and their foundations need to be built to be resistant to sideways loads. The lighter the building is, the less the loads. This is particularly so when the weight is higher up. Where

possible the roof should be of light-weight material. If there are floors and walls and partitions, the lighter these are the better, too. If the sideways resistance is to be obtained from walls, these walls must go equally in both directions. They must be strong enough to take the loads. They must be tied in to any framing, and reinforced to take load in their weakest direction. They must not fall apart and must remain in place after the worst shock waves so as to retain strength for the after shocks.

If the building earthquake resistance is to come from moment resisting frames, then special care should be taken with the foundation-to-first floor level. If the requirement is to have a taller clear height, and to have open holes in the walls, then the columns at this level may have to be much stronger than at higher levels; and the beams at the first floor, and the columns from ground to second floor, have to be able to resist the turning loads these columns deliver to the frame. One way of reducing the vulnerability of big buildings is to isolate them from the floor using bearings or dampers, but this is a difficult and expensive process not suitable for low and medium rise buildings and low cost buildings

Mr.Suman: Well said Kishore. What about Tsunami resistant building?

Dr.Kishore: How a building can resist flooding is best demonstrated by the 2004 Tsunami. All the fragile shacks built at ground level were simply washed away. Multi-storey buildings that were weakly built with no side-sway resistance were badly damaged. Some multi-storey buildings had their lower wall pushed in on one side, and out on the other as the wave went through, but otherwise, survived. Some buildings were pushed along where they were not fixed firmly to firm ground. But well-built buildings survived in the middle of areas that were otherwise completely devastated.

Nithi: Uncle, how to cope with surging tides?

Dr.Kishore: To avoid wave surges, the building should be built out of the projected water path; and this may mean building it on legs with a suspended lower floor level. Even if the elevation of such a floor is modest, the forces from rushing water will be much less if the water can go under the building as well as round it. The buildings should be on a narrow front, with gaps between them, and preferably not at right angles to the Beach.

Roshan: Uncle, can u tell me buildings to overcome heavy winds due to hurricanes and cyclones?

Dr.Kishore: When a building stands in the path of the wind, the windward wall tends to block the air, and the air pressure here increases. This force can cave in walls, smash doors or columns or bracing systems, or push buildings completely over. And a hurricane cannot be relied on to attack a building from only one direction. As it passes over, the wind can come from every direction.

Mr.Suman: How to overcome this?

Dr.Kishore: The foundations have to be big enough to resist uplift and sideways load. It helps to reduce some of the loads if there is some sort of venting for internal pressure, which can be caused by failures of windows and doors on the windward side. A length of ridge vent, away from the building ends, always has suction on the outside, so can help reduce unwanted pressure; but remember that any internal suction has to be added to the external pressure on the windward face. Suction loads generally are less than the pressure loads. But most components of buildings are stronger at resisting pressure than at resisting suction (tiles can easily be blown upwards, but it is much more difficult to blow them down through the roof. We have to take care on suction loads.

Mr.Suman: According to the Government of India, at least 38 cities lie in high-risk seismic zones and almost 60 per cent of the landmass of the subcontinent

is immensely vulnerable to earthquakes or other natural disasters. The fact that a large section of the population is poor and lives in houses and cities that are hastily built and are not earthquake resistance raises the risk of human impact, in case of any disaster. Also, the lack of government's preparedness to deal with such situations may add to the woes.

Dr.Kishore: That is true. According to the report not only India but 80 per cent of major South Asian cities are exposed to floods, with about 45 per cent falling in flood-prone areas and 14 per cent in extremely flood-prone areas. It also suggests that as much as half of all future urban expansion could be in flood-prone areas. Other than this, cities in Afghanistan, Nepal, Pakistan, and northern India that lie along the Himalayan range are all at risk of earthquakes. Many cities in northern India and Pakistan are also at risk of heavy inland flooding. This underlines the need for anticipatory planning and steps to mitigate risk.

Nithi: If so, what would be the mitigation strategies?

Dr.Kishor: The first step in developing a resilience strategy is to identify risks at national and city level. It is also important to identify the vulnerabilities of communities and potential exposure to disasters. Urban risk assessments aim to identify critical infrastructure and develop early warning systems. Mitigating risks call for developing both structural and nonstructural measures. While structural measures include dams, wave barriers and retrofitting of buildings etc, the nonstructural measures comprise policies and laws, practices, and agreements such as building codes, land-use planning, public awareness and information.

Mr.Suman: Homes also now are built to meet all environmentally sound criteria to reduce carbon emissions also. Governments have to reduce excise duty or give incentives for low emission cars and low energy houses.

Kishore: Yes. Mr.Suman. New housing from 2016 should minimize carbon emission.

It is done by ramping up of the thermal performance of homes.

Nithi: Now I have a clear idea on various Resilient Structures uncle.

Roshan: O.K uncle. Thank you for your valuable information on resilient structures. We are happy that we cherished some knowledge on sustainable homes. Come on Nithi…

We shall go home now. Bye...Bye..

(Bike sound and fade away)