Course: **Risk & Disaster Management in Construction** **Program: MS**

Exam: **Mid Term Exam**

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Ans Q#1.

Considering BRT (Peshawar) what were the risk involved during construction associated with technical aspect of project

Risks during construction associated with the technical aspects of the project

1. Extended duration of construction

It is evident that the longer the period of construction, the greater is the probability of occurrence of the hazards to which a project is exposed. However, in certain circumstances, there are seasonal hazards which occur at specific times of the year and thus require special consideration if the period of construction is to be extended. These hazards include rainfall, temperature changes, flood, storm and wind. To illustrate this point, the example of Diyala Bridge in Iraq may be cited. Designed as a prestressed concrete multi-span structure, it crossed a river known to flood during the month of April. The bridge was constructed using closely spaced formwork supported on the riverbed. The prestressing operation of the deck was scheduled to be completed prior to the flood season, but due to the permitted tolerances in the deck level being exceeded by the contractor in construction, the prestressing operation was delayed. The contractor attempted to rectify the levels, but in doing so he spent more time than he originally allocated for the construction of the deck. When the floodwaters finally arrived at the site, the restricted area of the river caused increased water velocities under the bridge, which resulted in severe erosion below some of the formwork supporting members under the end span of the bridge. In a very short period of time, the floodwaters swept the formwork downstream of the river. The end span collapsed into the riverbed. As usual, there were other factors that contributed to the occurrence of this episode, nevertheless one could focus on the issue related here as being the main cause.

2. Technical complexity and innovation in design requiring new methods of construction and/or erection

When traditional materials or methods are used in construction, the familiarity of those involved with the design or the work itself may permit an occasional ambiguity in the drawings or specifications without them being misinterpreted. It may even provide correction of a mistake. However, in a novel or relatively new design, material or construction method, what is needed is precise and thorough communication between the designer, manufacturer or contractor, as the case may be, and others involved in the construction process.

Examples cram the literature on failures. The brittle fracture of high tensile structural steel to British Standard 968:1962 was little known in the construction industry until load-bearing members designed for the Kleinwort-Benson building cracked one day in September 1965 as they lay on the ground in the fabricator’s welding yard.49 It was fortunate that this phenomenon was discovered at an early stage of using this material before a major disaster could take place. The most disturbing aspect of brittle fracture is that the metal breaks without warning at very low stresses with cracks spreading at a speed of 1,000 metres per second and often one may find it associated with welding.

In the precast concrete industry in the United Kingdom, the roof collapse of Camden School for Girls and of the reading room in Leicester University, within hours of each other, in June 1973, showed that the bearing distance between precast members and their supports must be of a minimum dimension greater than that allowed for in these two buildings. This minimum distance must be chosen not only for practical reasons of placement of steel reinforcement but also for accommodating movements in the various elements of the structure and for their lateral stability. These two buildings were in fact built in 1956 and 1965, respectively, prior to compilation of codes of practice in respect of the use of such precast concrete sections. However, the reading room in Leicester University was built after the collapse of four precast concrete buildings under construction in the United Kingdom and one of the reasons given in the technical statement made by the Building Research Station was ‘Bearing area of beam to column inadequate. Another serious consequence of the use of new materials and methods is that such use may create a problem in another area of design as is the case in high-rise buildings. The fire risk increased dramatically in the 1950s and 1960s due to the use of new materials in their construction. Prior to that period the infill elements of old skyscrapers were much more fire resistant and their masonry was non-combustible. There were no large glass surfaces which, when burning, would have permitted a fire to spread to other storeys from the outside.

Catastrophic fires were the result of the use of the aluminium curtain walls, plastic façade elements, large areas of glass, suspended fitted ceilings concealing large undivided areas and finally the use of synthetic materials. An example in this context is the large fire which occurred in São Paulo in a thirty-one storey building in 1972.

3. Removal of support

The risk of removal of support has usually very serious consequences, even in minor parts of the work, as can be seen from the following example.

A four-man gang was engaged in backfilling a trench excavated to lay a 229 mm diameter saltglazed pipe as part of a contract for kerb laying and surface water drainage on a road project. The side walls of the trench where the pipes were to be laid were supported by 19 mmthick plywood sheeting held in position by crossstruts. As the men prepared to take a mechanical roller along the bottom of the trench, they removed the cross-struts holding the plywood in place. Once the struts were removed, part of one of the walls collapsed, burying one of the labourers. The 21 year old worker died

4. Dangerous substances and items during construction and/or commissioning

The following example from Japan highlights the effect of such substances on construction work. Shortly after commencement, the construction of a water reservoir had to be stopped when the concrete cubes cast for testing purposes did not meet the required compressive strength and neither the concrete nor the cement manufacturers were able to give any explanation for the failure of the test cubes

The mystery was solved when it was discovered accidentally that the blossom and leaves of nearby Jacaranda trees had fallen into the concrete aggregate

Usually, concrete reaches 90% of its compressive strength within 28 days after manufacture. In this case, however, certain substances contained in the Jacaranda trees, although of minor concentration, apparently retarded the curing of the concrete. In another series of tests carried out later the compressive strength of the test cubes proved to be satisfactory.

5. Defective design

In September 1994, a ship-to-shore walkway in the Port of Ramsgate in the United Kingdom collapsed, killing six people and seriously injuring a further eight. The contractor was responsible for the design and construction of the walkway, but the cause of the accident was seen to be relating to the design of the steel structure

The walkway structure was hinged at the shore end and spanned two intermediate vertical supports fixed to a floating pontoon. The third span connected the walkway to the vessel. The construction of the walkway was in three sections, which were shipped to the site along with hinges and other fixing materials, where the whole structure was then assembled. The support bearings had to accommodate vertical and lateral movement caused by tidal changes, vessel roll and motion of the pontoon. It was reported that the two shore-end bearings and a third corner bearing at the first internal support allowed longitudinal movement along the direction of the span and rotation around a pin.55 The bearings on the fourth corner had two pins, one vertical and one horizontal, allowing rotation about two axes. Thus, the vertical pin at the fourth bearing provided the only restraint against longitudinal movement.

The accident occurred when the horizontal pin joint failed, thus disconnecting the bearing, and leaving no restraint to prevent horizontal movement. The structure’s integrity relied on a single 55 mm diameter steel pin, a 5 mm butt weld and a 7 mm fillet weld, one of which failed causing the bearing to fail.

6. Defective workmanship and material

The warranty of incorporating or using only good workmanship and material is implied in construction contracts. Despite that warranty, one finds that as long as quality means perpetual care and high cost, this risk of defective workmanship and material will always exist. Even the smallest defect can sometimes cause a disastrous effect, as happened in the case described below

The main distillation column of a new oil refinery became a total loss in an accident which occurred during erection.

The column, which was approximately 50 m in height and weighed over 120 tonnes, had been shipped by a cargo vessel from the factory to the refinery pier. It was moved to the erection site on low loaders. Two cranes with a capacity of 250 tonnes and 200 tonnes, respectively, were used to hoist the column into a vertical position and place it on its foundation.

During the initial phase of the joisting operation a third crane guided the base of the column. The foundation had been covered up with wooden planks to protect the anchor bolts while lifting work was in progress. When the column was suspended vertically a few centimetres clear of the foundation, the plank cover was removed. At this point the column made a slight turn, shifting out of position and sagging a little.

A weld in the cross-strut in the top section of the jib of the 250 tonne crane had failed, causing the failure of the welded joint and ultimately of the strut. The jib became distorted causing the column to turn and sag as described.

The operator of the 200 tonne crane, warned by the sudden movement, released the brake for the hoisting cable which deposited the column on the platform but leaning to one side. As a result, the 250 tonne crane was unable to carry the additional load and both cranes and the column crashed on to the ground sustaining irreparable damage. Other equipment on the site suffered damage which, when added to the cost of the column and cranes, amounted to $1.2 million. This collapse resulted from failure of the weld in the cross-strut of the crane.

Sometimes, however, such defects arise out of lack of knowledge rather than lack of care or intentional acts, as happened in the following incident. Aggressive material was shipped in 5, 000 plastic sacks each containing a weight of 50 kg. The sacks were heat-sealed at one end but, when they arrived at their port of destination, they were found to have burst open.

The cost of salvage and removal operations was very expensive due to the aggressive nature of the material being shipped. The sacks were examined and found to be made of a plastic material of a thickness of 0.25 mm. They were loaded on pallets with up to twenty sacks on top of each other. A chemical analysis carried out with the help of an infra-red spectroscope revealed that the sacks were made of polyethylene film with a density of 0.94 g/cm3. A tensile strength examination showed that near the heat-sealed ends the strength of the material was between 20% and 40% lower than elsewhere. This phenomenon, which is well known in the packaging industry, is caused by the fact that the films grow thinner in the area around the seams due to the heat-sealing.

The next step was to examine the way the sacks had been loaded on top of each other in the light of the above-mentioned inherent weakness. Calculations showed that, with twenty sacks placed on top of each other, the reduced tensile strength around the seams would already be exceeded under static load conditions. Considering the shocks and bumps hardly avoidable during loading and unloading, not more than a maximum of ten sacks should have been placed on top of each other.

7. Defective design, workmanship and quality control

During the construction of the rail link from London's Paddington Station to Heathrow Airport, the Heathrow Express line, three partly built station tunnels caved in during the early hours of Friday 21 October 1994 and continued to collapse over a number of days. Fortunately, no one was injured or killed in the accident, but the failure, which was estimated to have cost Heathrow Airport operator BAA around £50 million, brought chaos to the heart of the airport.

The station complex was to comprise three large caverns 9 m in diameter which form the central concourse area and two up-and-down-running platforms together with a complex network of tunnels and escalator shafts to link the station to the surface and to the main airport terminals.

At about 1 a.m. on the morning of the collapse, ground-monitoring equipment measured movements 'of the scale' which alerted workmen in the down-platform tunnel to the impending disaster. Twenty-five people were evacuated to the surface moments before the roof of the new station complex collapsed. Chaos ensued as the contractor's and consultant's engineers tried to contain and arrest the collapse and prevent further damage.

It was discovered that the collapse started at the base of the main shaft at the connection to the down-platform. With overburden material pouring into the fractured tunnel the semicomplete cavern was severely breached and the ground above swiftly sank. As the ground around the shaft slid into the down-platform, abnormal stresses were induced in the linings of both the concourse and the up-platform tunnels. These quickly began to fold up around the junction with the main shaft, causing further movement in the ground above.

To prevent further damage, the first task was to secure the stability of the main shaft. Structural concrete, at a rate of 27 truckloads per hour, was pumped into the shaft. This formed a 9 m plug at the bottom covering the tunnel accesses completely. Despite this, and despite pouring thousands of cubic metres of structural and light-weight foamed concrete, the ground was still sinking into the hole and eventually the site headquarters building tilted on its foundations and crumpled towards the hole.

Some 24 hours later, a rotary piling rig was employed to drill from the surface into the concourse and the down-platform caverns and more concrete was pumped through these shafts to plug the failed area. Access was gained to construct concrete bulkheads to seal the damaged tunnels. The flow of concrete into the hole continued the whole time until ultimately these measures were successful and ground movement around the failed area was stabilised. It was stated that by the end 18,500 cu m of concrete was pumped in.

The designers of the tunnel and the contractors were prosecuted under the Health and Safety Act in England for failing to ensure that their conduct during the construction of the tunnel did not expose the construction workers and members of the public to risk. The contractors pleaded guilty after an expert report, which was carried out for them in 1998, showed that a weak tunnel invert resulting from poor construction was the cause of the collapse. During the 27-day trial, it transpired that various warnings of an impending collapse were given, but these warnings were not heeded.

The final report of the Health and Safety Executive, published in 2000, referred to the accident as the worst civil engineering disaster in the UK in the last quarter of the twentieth century resulting from a catalogue of design and management errors, poor workmanship and quality control. The Executive claimed that the designers were responsible for monitoring the behaviour of the lining during construction and failed in their duty to issue warnings when data from their monitoring instruments showed that a collapse was imminent in the weeks preceding the collapse. The designers claimed that an ‘unpredictable and unpreventable’ landslide in the clay above the tunnels triggered the collapse and that even with a defective lining caused by poor workmanship, the tunnels could not have collapsed without an outside influence.

The jury found both the designers and the contractors guilty of the charges against them. The judge in the case, Mr Justice Cresswell stated that the contractors should bear the greater responsibility for the collapse, as they fell seriously short of the ‘reasonably practicable’ test. He stated that it was a matter of chance whether death or serious injury resulted from the breaches committed. The contractors were fined £1.2 million, whereas the designers were fined the lesser sum of £500,000 for their ‘less culpable role’.

A material factor in the collapse was the nature of the contractual arrangements, the contract management, and all engineering questions relating to the New Austrian Tunnelling Method (NATM) process in soft ground being devolved to the contractor with self-certification as part of a competitive contract.

7. Mechanical and electrical breakdown

Site operations are becoming more dependent on plant and equipment, the breakdown of which forms a major risk element. An interesting study was made of 409 failures of diesel and natural gas engines reported in the period from 1975 to 1979 with damage amounting to or exceeding US$2500. The study covers only such cases where the cause and development of the failure were clearly determined.Failures due to ‘unknown causes’ were not included in the study.

In some cases, the damage to the piece of equipment or machinery is minor when compared with the damage or risk of damage to the project itself, as occurred in the following case where the loss amounted to DM1.7 million.

A 2.3 km underwater pipeline with a diameter of 0.6 m was to connect a refinery on land with a planned tanker jetty. The pipeline was winched out from the shore by means of a steel cable. The winch stood on a moored pontoon. Then the cable became entangled and the winch was ripped apart. The pipeline, already partly under water, had to be salvaged. A cyclone then caused a tidal wave which pushed the pipeline some 200 m from its correct position to where it could be brought back only after a great deal of effort. Apart from this, construction equipment was also damaged. While a second attempt was being made to tow out the pipeline, the winch broke. At that point a length of pipeline measuring 1.3 km was in the water. The resistance caused by friction on the seabed had obviously been underestimated. It was not possible to repair the winch in the country itself and a reserve machine was not available.

Following this, tugs belonging to the harbour authority were used to tow the pipeline. Only approximately 400 m had been positioned in this way before the tugs were forced to give up. The next attempt was made with the help of a 16,000 tonne tanker used to tow the pipeline on its own. This also failed as, when the heavy ship started to move, the cable was torn by the force of the sudden jerk and the pipe sprang back and bent over.

These constant misfortunes led to a considerable delay in the laying operations. In addition, assembly became more difficult when the monsoon period began. The pipeline was finally towed with the original winch which had meanwhile been repaired abroad.

8. Inadequate site management

A company contracted to build a section of motorway procured the necessary stones from a nearby quarry. The rock was blasted into fragments and loaded onto dump trucks. The hydraulic excavator had a loading shovel with a capacity of 4.5 cu m and was driven by a 500 hp (DIN) diesel engine.

During operation, fire (probably caused by a short circuit in the 24 volt electrical system) broke out in the excavator. The flames consumed 1,000 litres of diesel fuel and an equal quantity of hydraulic oil in two tanks at the rear of the excavator.

Although fire brigades from the neighbourhood quickly reached the scene, it took an hour to extinguish the fire. The losses amounted to US$300,000. The fire could well have been brought under control at the outset if adequate fire-fighting equip ment (manual fire extinguishers) had been available. The loss, in that case, would have been minimal.

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9. **Ground movement**

Ground movement could take place from a number of causes, including landslides, frost heave, earth slips and ground pressure leading to collapse. Two examples are given here. The first occurred in a sewerage plant which was damaged during construction by an earth slip. Due to heavy rainfall the earth on the slope above the building site slipped down 10 m. The soil pressed against a shaft structure made of precast concrete elements until it collapsed. Consequently, surface water and silt were able to get into a sewer at the point where it had been connected to the shaft. The sewer had already been completed and was ready for use but then became filled with mud along a length of 2500 m.

The second incident occurred during construction work for new loading and landing piers which included the driving of steel sheet pile walls into about 8 m deep water and anchoring the walls on the landside by steel anchors. These anchors were held by a smaller sheet pile wall driven about 20 m further inland. When the driving operation was completed, the space between the two sheet pile walls was gradually filled with liquid soil. At the same time steel piles were driven along the waterside of the outer sheet pile wall, which were to be connected later by a solid concrete slab to form the final quay.

The ultimate fill height had nearly been reached when the inland sheet pile wall started to move. Deprived of its backward anchoring, the sheet pile wall on the waterside also gave way and collapsed over a length of 100 m pulling the inland sheet pile wall with it. Large amounts of fill material poured into the bay, tearing down several steel piles standing in the water. The damage amounted to about US$2 million.

10. ***Subsidence***

In 1975, an international consortium of contractors were awarded the contract for the construction of the terminus station in Hong Kong Island for the Hong Kong Mass Transit

Railway Corporation. The station, basically a large underground concrete box, almost half a kilometre long and approximately 27.5 m deep, was built in the central business district only a few metres away from surrounding properties. One of these buildings was the premises of the Supreme Court of Hong Kong which was built around 1910 on wooden piles in very poor ground.

During the diaphragm wall construction and after the sides of the excavation has been stabilised with bentonite, unexpected ground behaviour and dewatering influences caused the building to subside and tilt. Serious cracks appeared and in July 1978, when the learned judges had become concerned at lumps of plaster falling on their heads, the building was evacuated.

In 1984, the loss, which was calculated to be well into seven figures, was settled out of court, by the insurers. A single insurance policy had been arranged to cover the employer, contractor, subcontractors, and 'all other parties engaged to provide goods or services'. No subrogation recovery procedures were initiated and the insurers accepted responsibility.

11. ***Explosion and fire***

Even the best-organised construction sites are, by their very nature, prone to fire hazards. Inflammable construction materials such as timber, shuttering, packing material, plastic foils, fuel, paints and other hazardous material are generally found on site. The temporary nature of many items on site such as camps, stores and temporary heating and cooking facilities adds to the fire hazard. Moreover, only a few sites maintain complete and efficient fire-fighting equipment and many civil engineering projects are remote from public firefighting facilities. A project concentrated in one location can be threatened in its entirety by fire and the risk involved increases with the progress of construction.

Welding operations in an enclosed environment constitute a major fire risk both during and after the welding operation. The following incident of a fire that occurred during welding illustrates what could happen. An amusement park under construction within a hotel and shopping complex was almost completely destroyed by fire. The roof of the multi-storey 'theme park' was to be spanned by a 200 m×60 m glass dome. Among the attractions was a presentation of the Arabian tale of Sindbad the Sailor. The artificial rock walls used for the show consisted of glass-fibre reinforced polyester resin and were covered with a refractory coating on the front side only. The fire broke out during flame-cutting operations on pipework situated under the ceiling. It was thought that welding beads must have dropped on to the back of the artificial rock walls, which were at the time unprotected, and they caught fire immediately.

The workmen tried to combat the fire with portable extinguishers, but dense smoke and the toxic gases it contained soon forced them to give up. Large amounts of combustible material and the presence of a great many shafts for transporting installations, lifts, and escalators between the individual storeys accelerated the spread of the fire up to the glass dome.

Several hours elapsed before the fire brigade managed to extinguish the fire. Four of the approximately 300 workmen present in the building when the fire started suffered minor injuries. The fire caused considerable damage to the interior of the building, including its structural components, surfacing slabs, wall panelling and floors. Protective coatings covering the steel structure were affected by the heat and smoke and serious damage was inflicted to the mechanical and electrical installations, to lifts and to loudspeaker systems. The panels of the glass dome had to be cleaned or replaced. The material damage covered by CAR insurance amounted to the equivalent of about US$3 million.

In a similar incident, fire caused severe damage to a thermal power station designed to house three 400 MW units. The fire occurred many hours after the end of a day's work.67 At the time of the accident, the structural steelwork of the 29 m high machine hall was nearing completion and the equipment for the first unit was being installed. Concreting work for the third unit was under way. The foundations and steel columns had been completed and work was concentrated on the completion of the reinforcements and scaffolding for the turbogenerator platform. Concrete was to be poured the following morning and completion work continued late into the night.

In the early hours of the morning, a watchman on an inspection round discovered flames coming from the formwork. He triggered the fire alarm and fire engines were called from a nearby industrial area and the nearest town. The works fire brigade and another seven fire engines fought the fire, which was finally brought under control after one hour.

12. ***Vibration and oscillation***

A serious loss amounting to DM3.5 million occurred during the erection of one of the world's largest blast furnaces with a daily output of 8,800 tonnes of pig iron.

A self-supporting steel-plate, brick-lined chimney with an overall height of 140 m was to be erected for discharging the waste gases. The lower section of the chimney was 35 m high and cone-shaped, tapering from 9 m to 6 m in diameter. The upper chimney section consisted of a cylindrical tube having a length of 105 m and a diameter of 6 m. The material used for the steel plate was mild steel and the thickness of the plate varied from 12 to 30 mm. After the two chimney sections had been erected, the brick lining work was started. When the lining had reached a height of only a few metres, technicians discovered a crack, measuring 1 m in length, around the periphery of the chimney. The crack was at a height of 35 m, just below the joint between the lower conical section and the upper cylindrical section. Within a period of seven hours, the crack extended to a length of 8 m. The prevailing wind at the time was force 6 on the Beaufort scale and the risk of the chimney toppling over and crashing down on to the furnace air preheater unit could not be ignored. It was decided, therefore, after consultation with the insurers, to blast off the chimney approximately 15 m above the crack. This was done successfully, but how had the crack originated?

When checking the fracture and the design of the chimney, it was found that, due to severe oscillation of the structure, excessive stress had been exerted at the point where the conical and cylindrical sections met.69 Eventually, this had resulted in a brittle fracture of the steel plate. Wind tunnel tests, which could have uncovered the weakness, had not been carried out during the design stage.

13. ***Defective temporary works and their design***

A steel girder, used as falsework to support formwork, and incomplete bridge span sections, collapsed during construction of the second span of a six-span 300 m long continuous, prestressed concrete box-girder railway viaduct.

At the time of the collapse, all piers and one span had been completed. The steel girder was supporting the completed span and the moving formwork for the concrete box-girder into which approximately 40 cu m of fresh concrete had been placed for the first 10 m length of the second span. The form work was felt to drop suddenly and buckling was noticed in the web members of the lattice trusses which made up the steel girder. Buckling progressed slowly over a period of 30 minutes until the concrete box-girder section, which was two-thirds of its final length, was torn off near the pier and collapsed, together with the formwork. The completed piers and span were undamaged by the collapse.

The cause was traced to buckling of tubular web members in the steel girder side trusses. The girder, imported from overseas, had been originally designed to position and support precast concrete bridge sections slung beneath it. It had been substantially redesigned for use on the viaduct project, which necessitated a different construction method with the girder mounted under the viaduct span, and involved heavy loads and long spans. The affected side truss web members had not been strengthened and were loaded beyond their safe limit. There were no injuries in the collapse, but the financial loss sustained was approximately DM250, 000.

14. ***Corrosion***

A 63 mm stop valve was connected to a fire water supply line by means of an aluminium flange with a screw thread about 80 mm in length. The stop valve had a brass body of the material CuZn 39Pb2 whilst the flange was made of aluminium alloy G-AlSi10Mg. The quality of each of the two materials by itself was not in question, but when used together they result in galvanic corrosion when in contact with moisture and therefore leakage. This is precisely what happened on this project.

The water leaked through the localised corrosion in the joint and saturated the wall in the basement. To repair the damage, the soil outside the wall had to be removed and then filled in again afterwards. The wall also had to be dried and painted.

The loss, for which the water damage insurer paid, amounted to approximately US$15,000 and could only have been prevented by an electrochemical separation of the materials inside the valve. However, since as the valve could not be constructed in such a way, a different material should have been chosen for the flange. In this case, recourse action was taken against the plumbing firm responsible for this configuration.

15. ***Collapse***

Total collapse is the most catastrophic of all hazards. It rarely gives any warning and it therefore carries with it the risk of injury. Such an event occurred in Kuwait in 1976 when twenty-one workers were killed. The chain reaction, which resulted in the total collapse of a garage building under construction, lasted for just five seconds. Six parking levels collapsed like a house of cards. While the slabs fell on to each other to form a 'sandwich', the columns broke like sticks at each level and all that remained was a pile of wood, steel and concrete. What had happened? The formwork and reinforcement for the sixth floor of the building had already been completed. As a total of more than thirty floors had already been made in the same way, concreting seemed to be just a routine affair. The pouring of concrete for the sixth floor was thus started half an hour before midnight. The concrete was being pumped up through a riser. Some 70% of the slab had already been concreted around 6 a.m. when the timber structure supporting the formwork suddenly collapsed. As a result, the concrete, some of which had cured but other areas had not yet hardened, fell on to the slab below from a height of 3.5 m. The mass of falling concrete weighed no less than 450 tonnes.

The floor slab below had only been completed fifteen days earlier, but the form-work had already been removed. The floor was not able to support the weight of the collapsed floor and the dynamic load of the collapsing concrete masses. The columns buckled, and both floor slabs fell to the next level together. This induced a chain reaction, causing all of the six floor slabs to collapse right down to the basement level. The accident occurred while some workers for the next shift were still asleep on the lower floors and were thus crushed to death underneath the rubble. The workers doing the concreting fell to the ground together with the collapsing structure.

16. ***Collapse of temporary works***

On 5 August 1999, the £300 million Grand Bridge in South Korea partially collapsed and thirty-seven precast concrete bridge segments from one partly complete and two completed spans crashed to the ground.

The collapse occurred during construction of the 5.82 km section of the precast concrete segmental twin box girder southern viaduct. The viaduct, with 60 m long spans, was founded on twin 2.5 m diameter *in situ* concrete piers. The accident occurred as work was approaching the fifty-fifth pier and the 80 tonne deck segments were being assembled.

The segments were precast on site and transported along a previously completed bridgedeck before being positioned on a steel launching truss, which spanned adjacent piers and supported the segments making a span until all the segments were in position. Epoxy adhesive was then applied to the segment faces and external posttensioning was carried out stressing the segments together. The launching truss then slid forward to span the next pair of piers.

Peshawar BRT:

The first BRT (Trans Peshawar) system of KPK- Khyber Pakhtunkhwa which is right now under building by the supervision of PDA (Peshawar Development Authority) in the main city of Peshawar, a capital of province KPK - Pakistan. The project has divided into two distinct phases, in the main phase of the BRT system east -west corridor will be focused where 31 stations will be constructed with an initial deployment of 383 buses; Asian Development Bank has initially provided 88% of funding. It is worth mentioning that the Government of Khyber Pakhtunkhwa in 2013 submitted a request for maintenance from the Cities Development Initiative for Asia (CDIA) to develop Peshawar's urban transportation network which is badly disordered and mismanaged in all the way. CDIA entertained this request and quickly finished the Town Transport PreFeasibility Study that planned a 20-year city transport strategy, with a 10-year act plan. The CDIA thoroughly considered the aspect two passageways, a north-south passageway and an east -west passageway, and finalized has recommendations that the east-west passageway should be constructed first .Construction started under the supervision of PDA on 29 October 2017.

Literature Review:

A broad assessment of National international Project risk assessment and management was conducted during the initial phase of the study work. Formerly researches recommends that manufacture activities are mainly issue to more risks than other industry accomplishments because of its convolution; structure projects usually require a assembly of folks with altered skills and benefits and the management of a wide range of dissimilar, yet consistent, Accomplishments. Such Difficulties are more compounded by the exclusive Features of a project and many other external Uncertainties. And also, in Common, there is a Lack of literature that has motivated on the practices, effects or enlargement of risk assessment and management methods for Pakistani Production projects.

Risk:

In the middle of 1700 AC English language/literature picked the famous word “RISK” from French language, which is actually “risqué” in French. The assurance contract started using Anglicized meaning in 2nd sector of 18th century [V] and allowing to [VII] risk is concern to the happening of random future events whose careful probability and result is unsure but possible affect purposes of given situation in some way.

Risk Management:

It is explained as the systematic procedure and proper arrangement which is related to the competent management for achieving possible opportunities and undesirable impacts [X]. According to [VII] it is to be the practice of proactively functioning with shareholders to ease the danger and increase the chances related with project conclusions.

Conclusion and Recommendations:

To conclude, this paper has contributed to the construction industry of Pakistan as it has exposed and identified the risks involved in mega projects . Moreover, it has highlighted the adopted risk management practices and resource allocation methods implemented by different stakeholders of the construction industry of Pakistan. Stakeholders like Project manager, Planner, supervisor and key stake holders will be able to get information regarding different aspects of risk management associated to different construction activities. The paper has revealed that risk management system is less problematic instead of its implementation as per interviewer's exposures. Few mangers faced resistance to change as maintaining previous practices when tried to develop and implement the risk management system in their current organizations. Due to existing practice it was difficult to change the practices so early because of taking long time to change the culture adoptability. Therefore for developing and implementing it is essential to educate all stake holders. It is concluded that important project related risk on bases of priority are Error in design, Design Complexity, Prices Fluctuations, Tax rate, Poor Coordination, Pre- qualification and reputation of contractor, Key stakeholder relationships, Side condition unforeseen and finally delay or change in drawings supply.

The literature has also drawn some recommendations for risks related megaprojects like BRT. Some of them are as under:

a. To reduce/eliminate the barriers against risk management system, formal risk management system and Parties joint risk management system should be improved through conduction of study in local environments.

b. For Pakistani industries, international standards should be utilized to develop the risk management system for Pakistan.

c. Property developers risk management practices and their efficiency to local environment is to be studied and investigated.

d. According to Risk management level audit tool of Project management Institute (PMI), most organizations can described their current statues of risk management system and adequacy level between level 1 and 2 if measured. Local organization Maturity level should be improved through this study

AnsQ# 2:

Likelihood Categories for a Risk Matrix

Category	Description	Annual Probability Range
A	Likely	≥0.1 (1 in 10)
B	Unlikely	≥0.01 (1 in 100) but <0.1
C	Very unlikely	≥0.001 (1 in 1,000) but <0.01
D	Doubtful	≥0.0001 (1 in 10,000) but <0.001
E	Highly unlikely	≥0.00001 (1 in 100,000) but <0.0001
F	Extremely unlikely	<0.00001 (1 in 100,000)

Example Consequence Categories for a Risk Matrix in Monetary Amounts (US$)

Category	Description	Cost (US$)
I	Catastrophic loss	≥10,000,000,000
II	Major loss	≥1,000,000,000 but <10,000,000,000
III	Serious loss	≥100,000,000 but <1,000,000,000
IV	Significant loss	≥10,000,000 but <100,000,000
V	Minor loss	≥1,000,000 but <10,000,000
VI	Insignificant loss	<1,000,000

Probability category	A	L	M	M	H	H	H
	B	L	L	M	M	H	H
	C	L	L	L	M	M	H
	D	L	L	L	L	M	M
	E	L	L	L	L	L	M
	F	L	L	L	L	L	L
		VI	V	IV	III	II	I
	Consequence category						

GIVEN DATA:

Annual probibilty of occurance of event is (ID/6585200)

My ID CARD NO=14373 ,NAME Zahid ullah

If event occure ,the cost of the loss will be “45275000US$”

Requirment:

Risk level

Solution:

Annual probibilty value=14373/6585200

=0.00218

From table 2.1 we can select likelihood category

Likelihood Categories for a Risk Matrix

Category	Description	Annual Probability Range
A	Likely	≥0.1 (1 in 10)
B	Unlikely	≥0.01 (1 in 100) but <0.1
C	Very unlikely	≥0.001 (1 in 1,000) but <0.01
D	Doubtful	≥0.0001 (1 in 10,000) but <0.001
E	Highly unlikely	≥0.00001 (1 in 100,000) but <0.0001
F	Extremely unlikely	<0.00001 (1 in 100,000)

It show category "C"

Now to select consequence category. We will move toward table 2.2

Example Consequence Categories for a Risk Matrix in Monetary Amounts (US$)

Category	Description	Cost (US$)
I	Catastrophic loss	≥10,000,000,000
II	Major loss	≥1,000,000,000 but <10,000,000,000
III	Serious loss	≥100,000,000 but <1,000,000,000
IV	Significant loss	≥10,000,000 but <100,000,000
V	Minor loss	≥1,000,000 but <10,000,000
VI	Insignificant loss	<1,000,000

So from given table 2.2 it show "catagary IV" "significant loss" will occur

So To find out the risk level

Put the value in Figure 2.1

Probability category							
	A	L	M	M	H	H	H
	B	L	L	M	M	H	H
	C	L	L	L	M	M	H
	D	L	L	L	L	M	M
	E	L	L	L	L	L	M
	F	L	L	L	L	L	L
		VI	V	IV	III	II	I
	Consequence category						

From the above value it shows that the risk level is low and can be negligible.