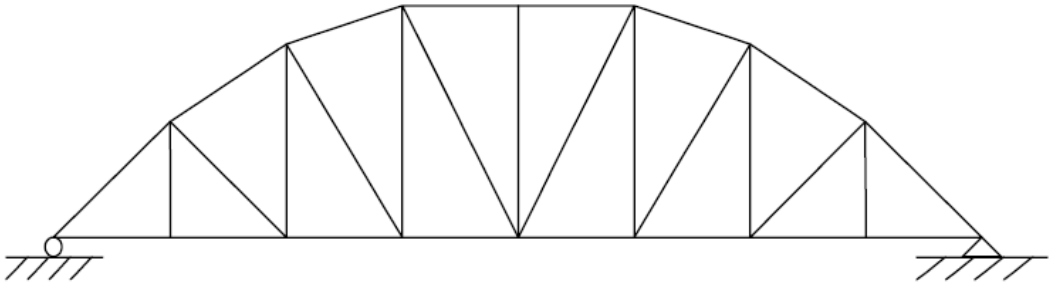
Risk Terminology Tutorial - Solution

Exercise 1

A truss as shown in figure below can be viewed as a structural system that must be designed to an acceptable safety level to support traffic loads on a bridge. The system in this case can be thought of as a system in series, meaning that if 1 out of 29 members fails, then the entire system would fail to function properly and may collapse. The failure potential is a serious matter that designers consider carefully in the design stage of the truss. Please share your ideas about any potential modes of failure and how you can manage the risks.

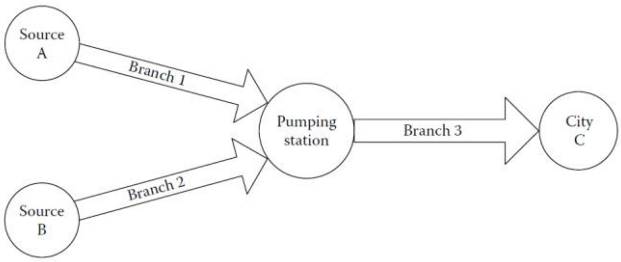


Solution

The design stage includes studying the possible scenarios of failure of the members in order to enhance the design and manage the risks. For example, a design could be enhanced to allow for partial failures instead of catastrophic failures and to introduce redundancy through the addition of other members to work as standby or load-sharing members to critical members in the structure. The benefits of such enhancements, which are intended to reduce the likelihood of failure, could include increasing design and construction costs to such an extent that the structure becomes economically unfeasible. Bridge failure consequences may be included in this analysis. Trade-off analyses can be performed to make the structure economically feasible and achieve the acceptable safety levels. This example demonstrates the potential of risk analyses during the design process to provide the acceptable risk levels.

Exercise 2

The primary water supply system of a city is shown in figure below. The water delivery system of city C has two sources, A and B, from which water passes through a pumping station. Pipelines (branches 1–3) are used to transport water as shown in the figure. Assuming that either source alone is sufficient to supply the city with water, failure can happen in branch 1, 2, or 3. Designers and planners of the pipeline system, therefore, have to identify possible water loss scenarios to assess the associated risks. Please develop scenarios and determine associated consequences for this case.



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Solution

The simplistic failure scenarios given in table below can be used for risk analysis studies of the supply pipelines. The table is limited only to cases where total failure happens in each of the three branches. The table can be expanded to include partial failures of a branch including water loss from leaks.

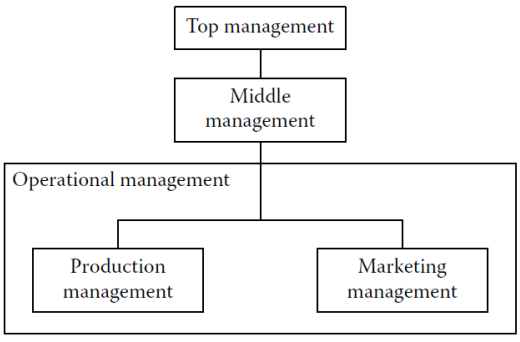
Failure Possibilities and Their Impact on a Water Pipeline System

Source of Failure	Failure	Impact on System or Consequences
Failure of branch 1 only	T	P
Failure of branch 2 only	T	P
Failure of branch 3 only	T	T
Failure of branches 1 and 2 only	T	T
Failure of branches 1 and 3 only	T	T
Failure of branches 2 and 3 only	T	T
Failure of branches 1–3	T	T

P, partial; T, total.

Exercise 3

Risk methods can be used to analyze potential failures in managing an organization due to errors, inappropriate decision, or incorrect decisions. Organizational failures can lead to significant adverse consequences. Executives and managers of organizations are responsible for designing the hierarchical structure of their organization. They should rigorously study the implications for designing their organizational structure as a system with in-series, in-parallel, or mixed series–parallel lines of authority and communications among departments and management levels. These lines represent the flow of instructions and the feedback channels that could fail and potentially lead to damage to the entire organization. For the series–parallel structure shown in figure below, you need to analyze the risks associated with the structure and perform failure analysis.



Solution

Performing qualitative failure analysis in organizational management systems poses a unique challenge, as managed departments are not mechanical devices that show a crisp transition from a functioning state to a failure state but rather exhibit partial failures and blurred transitions from one state to another. Therefore, in analyzing such structures, the percentage of failure at every management level has to be assessed through brainstorming and interviewing sessions. The qualitative analyses are usually a prelude to quantitative analyses to quantify these partial to disruptive failures as shown in table below.

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Possible Failure Scenarios for a Multilevel Organizational Structure

Source of Risk as an Adverse Event	Failure Scenarios	Failure of Top Management?	Failure of Middle Management?	Failure of Operational Management?	Performance of the Organizational Structure
Failure of existing structural hierarchy to achieve organizational goals	1	Yes	Yes	Yes	D
	2	Yes	Yes	No	P
	3	Yes	No	Yes	P
	4	Yes	No	No	P
	5	No	Yes	Yes	P
	6	No	Yes	No	P
	7	No	No	Yes	P
	8	No	No	No	S

D, disruptive failure; P, partial; S, success.

Exercise 4

In the event of a fire in an apartment that is equipped with a smoke detector, the potential consequences of the fire to occupants may be analyzed using qualitative risk analysis methods. The consequences of the fire depend on whether the smoke detector operates successfully during the fire and whether the occupants are able to escape. Develop the possible scenarios and assess the consequences.

Solution

The table shows possible qualitative scenarios that can be thought of as results of a fire. The table can be extended further to perform quantitative risk analyses by assigning probability values to the various events in paths (i.e., rows of the table). An additional column before the last column can be inserted to calculate the total path probability of each scenario. Such an analysis can assist planners and designers in computing the overall probability of each consequence for the purpose of planning, designing, and constructing escape routes more efficiently. Such analysis can reduce risks and increase safety to occupants of the apartments, leading to reduction in insurance premiums and enhancement of market values of the apartments.

Possible Escape Scenarios and Their Risk Consequences

Source of Risk as an Adverse Event	Escape Scenario	Smoke Detector Working Successfully?	Occupants Managed to Escape?	Consequences in Terms of Loss of Life
Fire initiated in an apartment	1	Yes	Yes	No injury
	2	Yes	No	Death
	3	No	Yes	Severe injury
	4	No	No	Death

Exercise 5

Consider health hazards of Salmonella enteritidis (ES), which is the second most common cause of food poisoning after Campylobacter. It has been found primarily in unpasteurized milk, eggs, egg products, meat, and poultry. ES can survive if food is not cooked properly. In the U.S., there are 19 ES-related human illnesses per 10^6 shell eggs consumed, 710 deaths per million ES-related illnesses, 47 billion

shell eggs consumed per year, the average cost of the illness is US$ 400 per case. Calculate economic risk (expected losses) caused by ES illnesses and mortality risks due to consumption of shell eggs in the U.S.

Solution

Frequency of illness: $(19/10^6)*(47*10^9)$=893,000 illnesses per year
Magnitude of death: 710 deaths per million illnesses (0.07% per illness)
Mortality risk value (expected losses): $893{,}000*(710/10^6)$=634 deaths/year
Cost per illness (regardless of outcome): US$ 400
Economic risk value (expected losses): 893,000*$400=US$ 357,200,000 per year.

Exercise 6

According to the U.S. Department of Transportation, in 2003, there were 6.3 million automobile accidents: 1 in 3 of such accidents resulted in injury, and 1 in 165 resulting in death. Assuming average loss of US$ 450,000 per death and US$ 25,000 of property damage for accidents involving fatality; average loss of US$ 15,000 per injury and property loss of US $10,000 for accidents involving injury; average property loss of US$ 3,000 for all other accidents, calculate the total monetary risk (expected losses) of automobile accidents per driver in the U.S. Assume that the U.S. population exposed to automobile accidents is 250 million.

Solution

Risk Contributor	Fatality	Injury	Other	Total
Probability per person per accident	$6.3 \times 10^6/250 \times 10^6 = 0.025$	0.025	0.025	
Probability of events given accident	1/165	1/3	109/165	
Probability of consequence per person	$1/165 \times 0.025 = 1.53 \times 10^{-4}$	8.4×10^{-3}	1.66×10^2	
Magnitude of consequence (US$ at risk)	450,000 + 25,000	15,000 + 10,000	3000	
Risk (expected loss)	US$ 72.54	US$ 210.00	US$ 49.94	US$ 332.49 per person–year

Case Study Tasks:

1. What was the main hazard in the case study?
2. What are the main functions of the process in the case study?
3. Are you able to estimate the likelihood and severity of the hazard?

Solution

1. The main hazard was overflow vapor in the production room.
2. The main functions of the system included heating, mixing, and ventilation.
3. At this stage, the likelihood and severity can be expressed qualitatively. The likelihood was low, and the severity was very high.