Prioritization of Lesson learned from Fukushima Accident using AHP

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1. Introduction

The Fukushima accident opens new horizons of knowledge for human to think and analyze such aspects of incidents that usually not occur in normal life. A critical examination of the accident reveals that the accumulation of various technical and nontechnical lapses only compounded the nuclear disaster. By using Analytic Hierarchy Process (AHP) the present research signifies the technical and nontechnical issues of Fukushima accident. The study exposed that besides technical fixes such as enhanced engineering safety features and better siting choices, the critical ingredient for safe operation of nuclear reactors lie in the quality of human training and transparency of the nuclear regulatory process that keeps public interest at the forefront.

In this paper a strategy to increase Nuclear Power Plant (NPP) safety has been developed. By using AHP, best alternative to improve safety and to allocate budget for all technical and non-technical factors related with nuclear safety has been investigated.

2. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a tool for solving multi-criteria decision problems. Analytic Hierarchy Process (AHP) proposed by Saaty [1] is very popular and has been applied in wide variety of areas including;

- Planning
- Selecting a best alternative
- Resource allocation and resolving conflicts

AHP applications are found useful when problems require considerations of both quantitative and qualitative factors. AHP decomposes the problem into small parts in order to facilitate the decision-maker in the appraisal task. First, a hierarchy structuring the problem is constructed. The top of the hierarchy represents the goal. Below we have the criteria, sub-criteria and alternatives. The appraisal can be constructed top–down or bottom–up but always using pairwise comparisons. Application of AHP to a decision problem involves four steps [2];

1. Structuring of the decision problem
2. Making pair-wise comparisons and obtaining the judgmental matrix
3. Computing local weights and consistency of comparisons
4. Aggregation of local weights

3. Strategy to Increase NPP Safety

We have developed a strategy to increase NPP safety by using AHP. By keeping in view the steps of AHP we have structured the problem by selecting the goal then criteria which is based on four factors including safety management, principal technical requirements, requirements for plant design and safety & reliability as shown in Fig. 1 For each criterion there are some sub criteria like for safety management the sub criteria are Quality Assurance (QA), Safety Assessment (SA) and Operational Experience (OE).

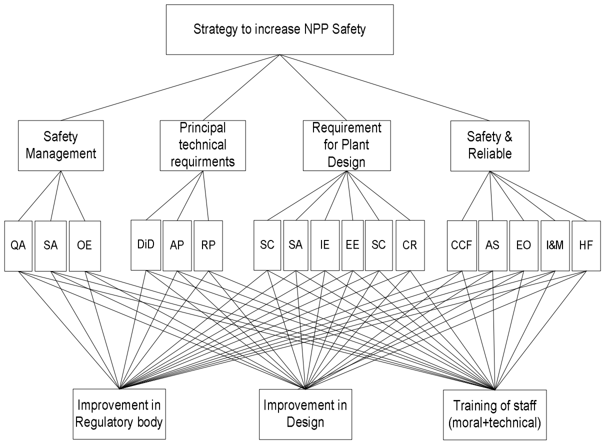

Fig. 1. AHP model to increase NPP safety

In the same way the other sub criteria are; Defense in Depth (DiD), Accident Prevention (AP), Radiation Protection(RP), Safety Classification (SC), Severe Accidents (SA), Initiating Events (IE), External Events (EE), Site Characteristics (SC), Control Room (CR), Common Cause Failures (CCF), Auxiliary Services (AS), Equipment Outages (EO), Inspection and Maintenance (IM), Human Factor (HF). At each step a pair wise comparison has been done. At the last step comparisons between alternatives and comparison of each alternative with respect to sub criteria, criteria and goal has been done.

A comparison among alternatives in view of sub criteria reveals that the best alternative to enhance NPP safety is to improve regulatory body by allocating more budgets. The second and third priority is the training of operators and improvement in design respectively. And the result of weight of criteria and alternative can be seen in Fig. 2.

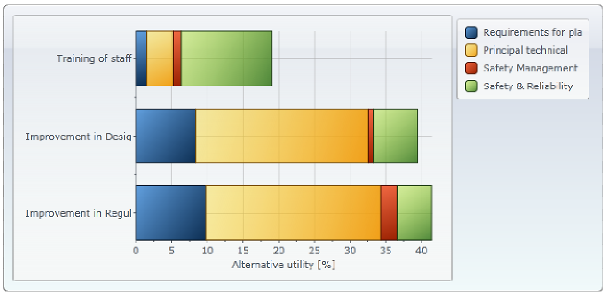

Fig. 2. Weight of criteria and alternatives in context of goal

4. Case Study of Fukushima Accident

A comprehensive study of Fukushima accident reveals that there was a series of equipment malfunction, reactor core meltdowns, and releases of radioactive materials. Lot of research papers and reports [3, 4] can be found which highlights different technical aspects of accident. But only limited data is available, related to qualitative aspects of accident. In this article the Fukushima accident has been investigated by using AHP and by keeping in view plant operation, design and safety. The best cause of accident has been explored with the help of expert's judgments. On the basis of these judgments the total budget can be divided in such a way that NPP safety & regulatory become first priority, then management and design respectively.

From Fig. 3 it can be seen that the sub criteria for plant operation divided into four classes as Human Factor (HF), Operator Training (OT), Dishonesty of Staff (DS), and Safety Culture (SC). In the same way plant design is categorized into three types including Emergency Diesel Generator (EDG), Protection against Disaster (PD) and Emergency Core Cooling System (ECCS). The safety related issues divided into Component Survivability (CS), Unavailability of Safety System (USS) and Deficient Emergency Response (DER). Fig. 4 represents the failure of regulatory body in context of plant design, operation and safety as criteria.

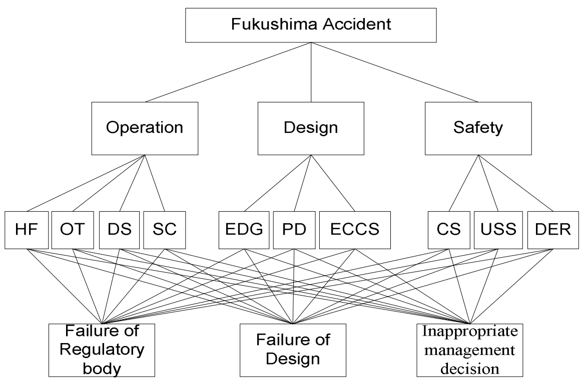

Fig. 3. AHP model for Fukushima accident

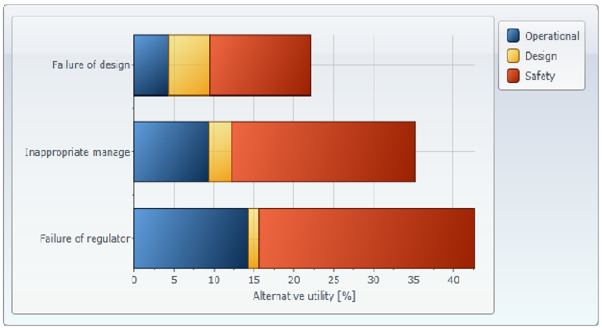

Fig. 4. Main cause of accident in context of criteria

5. Conclusions

By using AHP a methodology to increase NPP safety has been proposed. With the help of this technique the qualitative aspect of Fukushima accident has been examined by considering experts judgment. The results showed that a lack of regulatory authorities was one of the main causes of accident. So, more budget allocation in this area would be helpful to reduce accidents and to improve nuclear safety.

Even if AHP only addresses the qualitative aspect of safety factors, this study can be extended to quantitative evaluation with other tools such as fault trees or crisis trees so that the final results enable data-driven decision-making process, which is on-going project at Kyung Hee University.

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