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Memo on SMiRT (Seismic-safety Management in Real Time
Toward the SMiRT-26

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ABSTRUCT

"**R**eal **T**ime" matters mean not only the matters related to the affaires in time domain, but also the matters related to human behavior.

This short paper is an opinion paper and intending to talk about the future of SMiRT toward SMiRT-26, in 2021, the 50 year anniversary of SMiRT. Based on the serious experience on the Fukushima, 3.11 event, which brought the tragedy to the public in Japan as well as to the society of nuclear power. The point is as follows:

"Real Time issue" is the key for the future study of SMiRT, the Authors believe. We have been studying on various matters on structural problem since 1971, however, through the experience of the 3.11 event, we recognize that everything should be considered in time domain. After the critical event, it brought many failures to the plants, and also, secondarily it induced hydrogen explosions brought additional failures. To prevent such situation, we should study various problems related to "Real Time" problem. In this paper, it is going to be discussed what "Real Time" means, and how we should study it in next several SMiRT meetings to obtain the safer structural engineering.

BEFORE STARTING THE DISCUSSION

As known well, we, Japanese experienced very serious situation on nuclear power plants' disaster in March 11, 2011, so-called **the Fukushima, 3.11 event**.

This Paper has been prepared based on the following points as the Authors' thoughts their mind.

① There is always the possibility to occur a certain disaster over the level for their safety design assumed at their design.

② However, it does not mean to deny using any nuclear power plant.

③ Then, we should establish the standard practice to manage the operation practice on the plant as the standard procedure, not for accident management; so called AM practice.

④ Some problems consideration in time domain should be considered as RT; Real Time problems as follows: imaging the state of developing the disaster of geologically and historically recorded events, detecting related precursory event, sensing of occurring the event at the source before reaching to the site, estimation of response and behavior of the process and related structure in advance, general performance and counter measure of the system at the time; all subjects in time domains related to the plant safety.

⑤ Structural problem related to human behavior and/or structural degrading of the plant in the view point of the plant safety.

As mentioned above the 3.11 event brought to us completely a new philosophy to the seismic safety. They like to discuss how we, SMiRT should go and develop in the future, especially toward SMiRT-26,

50 years anniversary. To establish the seismic safety, we need the well organized management after we experienced the structural failure caused on all types structures not only classified as important structures. In the abstract, the author referred to "SMiRT" should stand for *Seismic-safety Management in Real Time.* We have been working for establishing the safe structures, not only building structure but all equipment and piping as well as other facilities, since 1971, the SMiRT in Berlin, and we believe most of structures were strong enough against hazardous earthquakes, but 3.11 event proof the hydrogen explosion destroyed four plants almost completely. Of course, the cause of these failures had been induced by Tsunami hazard to significant components for cooling down the cores, or fuel elements in the cooling pond（1F#4）. However, even if happened, is there any possibility to prevent to be such unfortunate situations; some numbers of people should leave from their home for a certain years, and those districts have been ghost town. Some days after the event, the author had a dream that he had been standing on the deck of a ship to look the ruins of main concrete buildings from the sea, as thinking the event one hundred years ago. The failure of the operations as the AM might be clear at that time in my mind.

To establish the seismic safety, as well as the operational safety against other natural hazards as well as all types natural hazards, our SMiRT should work for it, this is the role of the new SMiRT.

INTRODUCTION

As mentioned in the title of this presentation; SMiRT (Seismic-safety Management in Real Time), the real time of the operation of the plant by the operators are very significant to avoid the nuclear disaster like we, the Japanese experience in 2011. Several types of the survey reports and Video report from TEPCo show the situations of the operations, and we learned a lot. In this report, the Author tries to summarize the points of hazard and how to reflect them to the future SMiRT meetings. How we need to discuss them as the new key issues reflected those we have been discussing in the last SMiRT-21, which was held after 40 years since 1971. The current situation of our SMiRT meetings are not so good situation as those in 1980s and 1990s in some sense, as described in next section. The Author feels that some serious subjects shall be studied in next several SMiRTs to SMiRT-24, in 2017, which we are planning to have in Japan.

These subjects can be discussed only through learning the situation of the 3.11 event, by visiting and observing the Tohoku-area. It is 8 years later from now, but the situation surrounding the Fukushima #1 Station might be not improved well right now. Our engineers as well as scientists should know what we are facing, considering, discussing and solving toward a future through the activity of next several meetings of new SMiRTs. In 2021, we shall have the 50year Anniversary of SMiRT, and we should have a big SMiRT in Berlin for the further development of Nuclear Business and their Safety, with our experiences of unfortunate event.

Observation about the Current Situation of SMiRT and how should we find the new way for coming SMiRT

At the first SMiRT in 1971, Dr. H. Shah,;Prof. of Stanford University and one of the Authors Shibata had been working as the chairmen of the session for the engineering seismology in Division K. However, the papers of the engineering seismology had been decresing conference by conference.

One of the Authors wrote a paper on recent significant subjects of earthquakes and related matters to the seismic safety for plant engineering; especially for NPP [1)] in 2006. In the paper, he referred to the importance of the knowledge and understanding on engineering seismology for establishing the seismic safety of engineering critical facilities, especially NPP. And also he mentioned about troubles of, plant fire and other seismically induced events in engineering plant.

Five years later, the Fukushima 3.11 event had occurred. And we have been feeling the necessity to well-understanding knowledge on engineering seismology and establish the own knowledge and understanding on expected result of hazards. And we should know how our systems are going to have their accidental states, not only in structural parts but also in process. Those, development of catastrophic state is the matter in time domain

Approximately, 30 years ago, ICONNE had been organized by ASME and JSME, and some years later the French society joined to it. Their activity had been developed towards the practical engineering for those of NPP, .and the most of participants to SMiRTs have been moved to ICONE conference, gradually, except those in civil engineering..

ICONE-21 will be held in Chengdu, PRC in July of this year and developed to the almost same size of the previous SMiRT. Some fields, which we have been discussed in SMiRTs moved to their activity. Our SMiRT cover the structural engineering matters in Civil engineering, of course, but already we have been working for these engineering already 62 years since 1971, the 1st SMiRT in Berlin.

At the Berlin, there was a session on sitting in relation to engineering seismology as mentioned above, but since that our main interests have been gone to the more mechanical and structural engineering sides.

For those subjects we have had enough chance to study and discuss in various occasion. After we experience the 3.11 event, we feel the necessity on the discussion of the real-time plant safety. So, the Authors are discussing the development of SMiRT towards the new SMiRT; that is "**S**eismic-safety **M**anagement **i**n **R**eal-**T**ime".

SEISMIC-SAFETY MANAGEMENT IN REAL TIME

What is "real time"? The authors referred to the emergency shut down by sensing the P-wave motion of earthquake and improving it by using the newly developed as early warning system by JMA, the Japan Meteological Agency, and also the emergency control system fot the Shinkansen; the High-speed railway system by JR, in the occasion of the WS for WA-3, EBP, ISSC, IAEA in Mumbai in 2010 : "*The Seismic Trigger System is a Kind of Prediction System*".[2)] At the time, "Real Time" is only the matter in second. And this subject has been developed through the activity of those EBP and the second WS was held in Dec. 2011[3)].

Recently, we have been discussing about the potential activity of fault like geological structure in the NP Plant area. The Nuclear Regulatory Agency, NRA, which were organized in September 2012, last year, is now requesting to prohibit the operation of NPP, if we find any fault which might be active in the last 400,000 years. They treat that it might be active fault, if we cannot find the evidence of no movement last 400,000 years or more. We should make clear whether or not the fault might move right now; in real time. In this case, Real Time is a moment of some hundred years span, which is different from the span for the seismic trigger system, which we made discuss in some previous papers. If we consider in this way, the concept, or issue of "Real Time" may be expanded wider. . Our SMiRT has been working for the countermeasure against natural hazards like earthquake from the beginning, but we also consider various kind of natural hazards for the structural safety of various type structures in the plant. In any cases, we have a possibility for meeting the beyond-the-design condition. Then we should operate the plant as AM mode, like the 3.11 case. And for the preparation, we need for various situation, like tsunami, heavy rain, volcanic activity and so on, the scales of "Real Time" are different to the time scale of individual events, from seconds to some hundreds years

Again the Authors want to talk this as follows: Some problems under consideration in time domain should be developed as

RT; Real Time problems ,

✻Estimating and imaging the state of developing the disaster state on geologically and historically recorded events, as exactly as possible based on fact and evidence,

✻Detecting related precursory event,

✻Sensing of occurring the event at the source before reaching to the site,
✻Estimating the response and behavior of the process and related structure in advance
✻*General performance and counter measure of the system at the time; all subjects in time domains related to the plant safety.*

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After the 3.11 event, we have been feeling the necessity to establish the new management procedure and system on plant operation procedure and system for various situations under foresight of those events. This is a part of the job of SMiRT. Someone mentions that this is a job of the safety engineer, but for the design of operation system and procedure, we should foresee the scenario of occurrence in the plant under the hazardous condition, that is, a job of the SMiRT engineers (We are expecting the Second WS would be held in this SMiRT regarding to this subject).

With lack of foreseeing the state of the damaging of the plant under the hazard condition, no one can design the system and their operation, at all.

ONE of the KEY ISSUESES for the WORKS of FUTURE SMiRT;
Probabilistic Risk Design, or Counter-measure Design against the Expected Maximum Hazard?

The new Nuclear Regulatory Authority, NRA has been requesting the design of the counter measure system or devices of plant through Japan. The new codes will come out in this July. For this operation, the maximum hazard, which we are expecting, should be considered to avoid to the worst plant conditions, so as to be the design of their facilities should enough. Commissioners of new NRA is requesting that the plant owner should consider the worst case, for example, the height of Tsunami for the anti-tsunami wall should be higher than that have been ever experienced or might be experienced in the coming future. In this case "the height" includes all figures which we are expecting to be in any means without any systematic approach.

Tokyo PSAM 2013 is planning to have the Conference on "the Nuclear Safety and Risk Evaluation Approach" Apr. 14～18 in Tokyo, as well as some discussions which are planning to talk about the meeting of the WA on IAGE OECD/NEA; IAGE in Paris in the same week. Some result of the conclusion of those meetings would be reported in August, by reasonable access.

We can find another same type discussion on the instruction by NRA. That is the problem of a potential active fault in the site. The point is as follow: Dr. Shimazaki, one of the Commissioners, Professor Emeritus of University of Tokyo, seismologist has been pointed out faults in areas of several nuclear power plants, such as Tsuruga, Japan Atomic Power Co., might be the active faults, that is, which might be slipped in some hundred thousand years ago, at least, he pointed out with some results, he obtained through his observations, with other specialists in some cases. Therefore, the plant should not be operated. The code related to such discussions will be completed in this July. Currently, at the end of March, all related power companies have never operated by the judgments of nuclear power plant owners. The point of discussion here, there might be some gap in the conjunction between the requests from the NRA and the systematic scientific reason of their requirements. *Is this fault like structure here is "active fault" really?*

By the way, the Author has been working and organizing of the international workshops on deep-bore hole study together with JNES since early 2000s. Through this study, some surveying the potential activity of fault by using deep-bore hole may be more positively solve and conclude this problem; "Activity of fault structure in the plant area".

Who does request the Current regulatory matters to the Power companies on the Structural Safety on NPP, and How?

In the discussion described in the previous section, it seems to be the role of a particular commissioner might be a key to be solved. Another example, the Author like to pointed out. A recent news paper

reported for a political topic trouble by the direct order from Prim-minister at the time, by skipping the opinion by specialists and officials. The News paper pointed out on an ordinary political matter, but it is true even for the operation of the 4 units of Fukushima #1 at that time. The Prim-minister, Mr. Kan at that time was an engineer, graduated from Tokyo Institute of Technology, one of top engineering schools in Japan, tried to managed the plant operation at that time through the discussions with the operators and the Director of the Fukushima #1 station, TEPCo. Can you believe this news?

In the situation of the NRA is some similar situation, some effect of a specialist might be too strong to decide its policy. Some similar situation might be found in the situations in 1970s and 1980s in the Eastern Europe, the Author experienced through the mission of IAEA. .

SMiRT need to discuss on the Safety Culture of the Society, which the Author has been discussing in 2010 before the 3.11 event, but now we need to discuss how the Government control the Safety Problem. We, our SMiRT should discussed and control how to control the seismic safety; maybe, including other-type hazard induced emergency situation of NPPs by the Government as well as operators. Currently the Government as well as NRA are trying to control the operation of the NPPs all through the Nation in Japan based on the Office of NRA (anticipated?)-based their philosophy. We need to establish the adequate criteria for the various kind of natural hazard. As our result induced by Tsunami in 2011, the 3.11 event, we, Japanese should carefully discuss about this problem, but it might be not so common for all countries.

Some other issues related to the real time managements in such cases are in next several chapters.

WELL-TRAINED PERSONNEL or COMPUTTER?
To Avoid the Diverging Abnormal State of the Plant

Some years ago, 30 min. rule or some similar type operation rule was discussed. That is, in the case of emergency, the operator should not do any thing in next one half of hour to avoid his miss-judgment. The system shall do everything with their correct judgment. This principle may be still remained in the principle for the plant operation. This approach is established without no other failure on the system. In some case, including the 3.11 event, this principle might be doubtful, but it might be true in some case.

Design by Definition and Replacement of the Safety System after Some 40 years use and Training on Use of Older System

In the 3.11 event, the operation of Isolation Condenser, IC of #1 plant is one of the critical event. At that time, no one could recognize whether or not IC was operating as normally in the accidental state. And without confirming the exact situation, they went to next step of operation for to release the accidental condition. None of them were seemed to recognize the function of this heat exchanger, that is, Isolation Condenser; in Japan, after 3.11, "IC" is translated to *"emergency heat exchanger", but few people seemed to understand its function and characteristics*. The exact safety function, *isolating of secondary coolant from radioactive situation contacting fuels and other radioactive materials,* of this system was not understood. Even, the term of containment vessel, C/V had not understood in the case of TMI accident, then, afterward, we found the necessity of "vent system with filter for radioactive" after the event. Even so, in the 3.11, there were many difficulties to open them, and no filter had been prepared.

These items were named and designed by their simple functional requirements. And no one considered their overall characteristics at the beginning, that is, *for C/V it might be another key example of such situations;* the requirement to reduce the internal-over pressure in a containment vessel was not considered before TMI event, except the function of suppression chamber or ice condenser, in Japan never until the 3.11 event.

Two cases above are the examples of "design by definition". Their primary function is designed as its name, definition, but no other consideration was made for the safety at the beginning. For well planning this point, the planner and designer need to fore-see the state of events, which we should expect, the Authors defined it as "Scenery", and this concept was employed for the Standard of PSA by AESJ.

In relation to this, the Authors want to mention the following two points; one is replacing the safety system including the control system. We often discuss the life of the plant in the view point of their pressure boundary, currently 40 years in Japan, after the 3.11 event, but the control system including the safety device as well as their concept, in some cases.

The related engineers, including the operating personnel, usually have been never working at the workshop in the same situation for 20 years. If he/she works for the design, after 20 years he/she might be leaving from the original position, then, lost the chance to operate such emergency system, and it becomes a role of some new comers. And they should think about the original thought of the plan, or design even in emergency situation.

Regarding to such points, we should discuss and establish the design approach as the scheduled way. This is one of the key issue for the subject in Real Time domain problem.

OLD GOOD DAYS

The Authors have been trying to find some new subjects for SMiRT in relation to the subject of AM on plant emergency induced by natural hazards. In Fukushima #1, the operators and related engineers had not understood well their real function of its emergency heat exchanger, so-called IC, as mentioned in the previous chapter. In 1960s～70s, we had had enough time to discuss a subject with colleagues in various fields about their safety system. On a particular subject like a roll of IC, for example, one of the Authors had much chance to know it in the process of studying the seismic design of plant equipment. But we do not have a chance to discuss with engineers and scientists for the safety related to natural hazard freely like friends, as before. Also, he had been experienced to discuss on the fundamental philosophy to establish the concept of "Seismic Safety Guide and Criteria" with Senior Professors: like Drs. Housner, Newmark, Muto, Kanai and Hisada in 1960's as well as Old SMiRT members since 1971. The Authors believe that we need to discuss much more for reconstruction of the skeleton for designing and constructing hazard-free plant. Of course, we, engineers in Japan, are working together with scientists for the regulatory matters, like an active fault in plant area, but they are required to be independent rather working together, because of the requirement of independency; engineering professors who are related to the business of NPP and scientists like seismologist.. We, engineers in nuclear engineering and scientist need to be good friends, as in old days..

CONCLUDING REMARKS

This is some memo on the Authors' thought on the 3.11 event; The Great East Japan Earthquake and Tsunami, and the following Accident Management of NPPs. The Authors presented the Real time problem related to the emergency shutdown system of NPP in the WS and their EBP meeting in the Summer and Fall of 2010 organized by International Seismic Safety Centre, IAEA. This Activity has been developed the work of WA3 as Table 1.

Key issue, by the Authors, have been discussed in the previous chapter, already. He believes that it is the key for the New SMiRT to reconstruct and to understand, and also to re-establish the good co-operations between the scientists and engineers, at least in Japan, but it might be in the World.

At the end of March, almost every day, some news papers have been reporting and discussing on new issue from the NRA in various scientific and engineering levels. Our SMiRT should also discussing on the regulatory way in each country based on their Safety Culture, but also to meet the adequate level of the absolute safety. This is not so easy task and job for all of us, but the Authors are expecting to establish our new mode toward SMiRT 26,

Table 1 Activity and Detail of WA3, EBP, ISSC

Working Area	3
Working Group	3.2
Task/subtask name	Task 3.5: Real-time safety assessment system (RTSS) to evaluate NPP's response when subjected to external events
Task Leader	Hiroshi Abe (JNES)
Task Co-Leader	Victor Kostarev (CVS)

Objectives:

• First step: Study feasibility to evaluate whether a system* can be developed to assist the NPP operators in decision making just before or following a strong earthquake, to mitigate potential effects of earthquake.
*In the occasion of recent Japan earthquake, the similar early earthquake warning system for the high-speed railway successfully worked to slow down or stop the trains before the arrival of strong motion of the earthquake.

As for nuclear power plant, the system could have various aim, scheme and function.
For example;

Minimum level: Automatic safe shutdown system at earthquake as High speed railway
Maximum level: Display system to the operator what are the most probable failure sequences, plant status and critical recovery actions needed with highest priority at earthquake and/or other external loads as water flooding, hurricane, tornado and aircraft crash etc; by hi-speed, hi-reliable real time computing device of seismic PSA or equivalent safety analysis, using plant parameter.
Regarding minimum level, automatic shut-down system is already incorporated into some actual NPP
Regarding maximum level, state of art speed and reliability of computing device seems to be not enough.

• Second step: Produce a technical report investigating concept, function and scope of RTSS, if the system seems to be feasible
• Third step: Produce a technical report contributing to the technical basis for planning such a System

Scope:

First step (2011-2012):

Feasibility study composed of;

a. Survey on hi-speed computing system example capable to handle plant parameters in task member countries, current status and future perspective
b. Survey on application status of Seismic PSA and equivalent safety analysis for NPP in ditto
c. Survey on NPP shutdown system at earthquake and other external events in ditto
d. Survey on NPP plant parameter monitoring and display system in ditto
e. Feasibility discussion based on a to d

Second Step(2013-14) First step : Feasibility study report of RTSS

Third Step (2015-): According to result of first step and second step

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APPENDIX; on "Early Warning System" [3)]

"Early Warning System" of hazardous earthquakes was developed by Japan Railway Research Institute as the automatic train control system for Shinkansen train, the high speed railway system between major cities in Japan, They found the relation of the tendency of starting up rate of the ground motion *vs M* : Magnitude of its main shock or event, then the amplitude of the main shocks. The amplitude of the main shock, of S-wave motion can be estimated in advance; the Automatic Train Control System is going to activate to stop the train in advance the catastrophic state. This relation has been developed into the Earthquake Warning System by JMA (Japan Meteorological Agency) for the warning in advance to the shaking. WA3 research group, ISSC, IAEA has been studying this subject as the Seismic Safety system, based on the discussion made by the Author in the WS in Mumbai in June 2010.

Introducing the Early Warning System for Tsunami is developing and discussing in WA3 now, and the Author tries to summaries the current status for NPP.

As an accident management, the real time behavior of operator is significant under emergency condition is significant. By chance, one of the Authors observed the behavior of operational personnel induced by a total blind of all CRTs except one in some country, and he felt that their behaviors and response might be a problem.

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