REAL-TIME TEMPERATURE MONITORING AND SIMULATION OF CONSTRUCTION PROCESS BASED FEEDBACK DESIGN OF TEMPERATURE CONTROLLING MEASURES FOR CONCRETE DAMS

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ABSTRACT

Years of Research has demonstrated the close link between cracking and temperature variation process within mass concrete. To prevent cracking, years of practices and in-depth research have been conducted on revealing mechanism of temperature cracking and effects of various controlling measures. However, concrete cracking is not vanishing consequently. It is still trapping engineers. For instance, during design and construction of Xiaowan double-curvature arch dam in China, strict measures have been incorporated in materials and construction technics to prevent cracking according to experimentation and simulation results, but 16 cracks were found in 6 monoliths in the initial stage of construction.

From previous research, some important facts that have been increasingly attracting most scholars' attention are as follows:

(1) To have an overall understanding of the developing process and distributing pattern of temperature stress, the variation process and distribution pattern of temperature fields must be accurately defined.

(2) The accuracy of concrete thermal parameters and environmental parameters involved in initial conditions and boundary conditions are remarkably contributing to simulation results of temperature and stress fields. Moreover, in most practical cases, due to the variation of construction scheme, real boundary conditions of each concrete block might be significantly different from on which the temperature and stress simulations are based. Accordingly, more valuable results of temperature and stress simulation should be based on more accurate parameters of the simulation process.

(3) The most concerned factor during construction is the effect of temperature controlling measures for concrete dams. Therefore, to fully utilize monitoring data for predicting risk zone and guiding engineers to take steps as early as possible to prevent the occurrence of undesirable cracks is of great importance.

For these reasons, an integrated concept, named feedback design of temperature controlling measures, which incorporates temperature real-time monitoring, temperature simulation, construction process simulation and optimization of construction measures as a large system is set up in this paper. On the basis of this concept, feedback design of temperature controlling measures for concrete dams is done along the following steps:

(1) monitoring temperature variation process and collecting data through distributed temperature sensors embedded in typical concrete blocks;

(2) reconstructing temperature fields and back analyzing thermodynamic parameters of construction materials according to collected temperature data;

(3) simulating dam construction process by incorporating construction scheme parameters with quality restriction to obtain accurate parameters of construction schedule for determination of accurate constructing environmental parameters;

(4) simulating temperature and stress fields within dam concrete by incorporating initial temperature controlling measures, material parameters from step (2), environmental parameters from step (3) and construction schedule from step (3) to predict distribution and other details of temperature fields and stress fields;

(5) assessing effects of initial temperature controlling measures by comparison with results from step (4) and temperature design standards to determine revised measures if design standards are not satisfied;

(6) if there are revised measures, repeating step (4) to step (5) until temperature design standards are satisfied.

Works from step (1) to step (6) are repeated in each concrete block to propose individuated controlling measures for respective concrete blocks.

Our research team takes Xiluodu arch dam as a study case and implements the above works from the commencement of dam construction in Mar. 2009. Construction of this dam will be completed in May. 2013. So far the results of the feedback design approach have been proved efficacious.

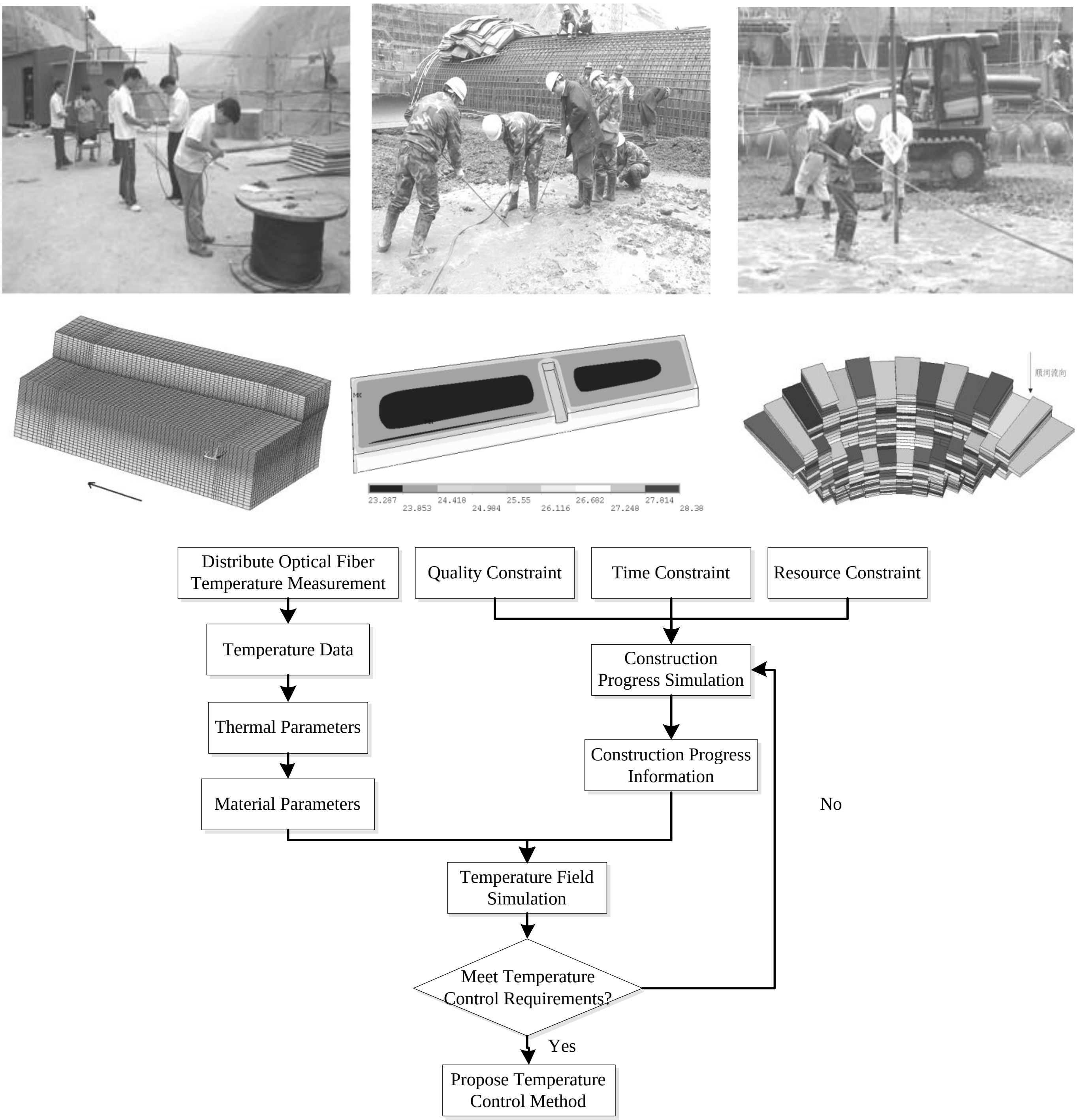

Figure 3: *Temperature Control Method Optimization Flow*

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HYDRO-ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE IN LARGE RIVER BASINS IN KOREA

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Abstract:

The hydro-environmental projection corresponding to water resources availability in the major Korean multipurpose dams based on the IPCC climate change scenario(A1B) is suggested. The projection by 2040 for precipitation and dam inflow gives 7.8~13.1% and 6.7~24.6% increase. The inflow projection for 7 major dams shows highest increasing ratio of 24.6% in Chungju and lowest of 6.7% in Juam, and 13.6% increase on the average under the Foreseeable Future scenario. The dams (Soyanggang and Chungju dams) in Han river basin shows relatively higher increasing trend than the dams in the other regions, Nakdong river basin in particular. As a result the availability of surface water resources can be expected to be improved, but, at the same time, the vulnerability against flood risk can be aggravated. The hydro-environmental impacts are lowest in Juam. Sediment impact is expected highest in Soyang. Total-Phosphrous impact is relatively low in most areas, but highest in Imha.

Keywords: *Downscaling, Climate Change, Water Resources, Artificial Neural Network, SWAT*

1. INTRODUCTION

The hydro-environment depends largely on hydrologic cycle and is impacted directly by climate variability and change. The regional projection using GCM (Global Climate Model) accompanies significant amount of uncertainties which are propagated and amplified when the projection is extended to applied dimensions using impact models.

In this study, the hydro-environmental projections in the 7 major Korean multipurpose dam basins based on the IPCC climate change scenario(A1B) will be suggested. The coupled downscaling scheme consisting of ANN (Artificial Neural Network), NSQM (Nonstationary Quantile Mapping), and STS (Stochastic Typhoon Simulator) sub-modules was applied for the regional daily hydrologic projection. The basin inflow to the dam reservoir was computed using SWAT, the long-term continuous rainfall-runoff model which is one of most popular models used for climate change impact models.

2. REGIONAL DOWNSCALING FOR GCM OUTPUT

The RCM (Regional Climate Model) output for the future climate scenario was provided by KMA (Korea Meteorological Administration). It has 30km of spatial scale and provide daily scenarios to the public. The KMA's RCM was developed by calibrating NOAA's MM5 to Korean climate environment and coupled with ECHO-G model. It provides scenarios of 5 atmospheric variables; precipitable water, relative humidity, temperature (average, minimum, maximum). As the emission scenario for the projection in this study was SRES A1B of AR4.

The ANN is one of the MOS (Model Output Statistics) tools for calibration of regional biases embedded in RCM or GCM (Kang and Lee, 2011; Kuligowski and Barros, 1998). The predictor variables for input to the ANN are precipitable water, relative humidity, temperature (average, minimum, maximum). Additional data fitting was implemented with NSQM which utilizes the temporally variable statistical parameters reflecting the variable trend captured by the original RCM, thus more realistic projection with seamless connection with baseline scenario fitted to historical observation. The GCM or RCM does not include the local heavy rainfall and typhoon generation mechanism, which can be a reason of underestimation for the summer precipitation (Cheng, et al., 2009). The uncounted typhoon rainfall by GCM was simulated for the projection period using the STS which generates occurrence (and duration) and intensity of typhoon using the mixed Poisson and Gumbel distribution, respectively (Moon, et al., 2012). The projections of annual precipitation at multipurpose dam basins are suggested in Table 1.

Table 1. Projection of annual precipitation at 7 major multipurpose dam basins in Korea

unit : mm

Dam	Baseline(Obs) 1991~2010	Baseline(Sim) 1991~2010	Foreseeable Future (2010~2040)	Mid-Term Future 2041~2070	Long-Term Future 2071~2100
Chungju	1445.4	1449.7 (0.3%*)	1651.1 (13.9%**)	1800.3 (24.2%**)	1998.3 (37.8%**)
Soyanggang	1459.0	1452.6 (-0.4%*)	1714.9 (18.1%**)	1900.5 (30.8%**)	2119.4 (45.9%**)
Andong	1245.2	1245.6 (0.0%*)	1379.9 (10.8%**)	1520.8 (22.1%**)	1720.0 (38.1%**)
Imha	1103.2	1105.1 (0.2%*)	1227.8 (11.1%**)	1393.2 (26.1%**)	1577.9 (42.8%**)
Hapcheon	1324.3	1349.9 (1.9%*)	1500.6 (11.2%**)	1747.3 (29.4%**)	1974.6 (46.3%**)
Namgang	1474.6	1481.7 (0.5%*)	1622.4 (9.5%**)	1811.3 (22.2%**)	2018.1 (36.2%**)
Juam	1501.6	1502.2 (0.0%*)	1619.6 (7.8%**)	1664.5 (10.8%**)	1788.1 (19.0%**)

*Percentage of Baseline(Obs)

**Percentage of Baseline(Sim) by periods

3. LONG TERM HYDRO - ENVIRONMENTAL PROJECTION AT THE MULTIPURPOSE DAM BASINS

The long term water budget and hydro-environmental impacts were computed using SWAT, the continuous watershed model. The HRU (Hydrologic Response Unit) was used for the sub-basin delineation. The simulation was carried out daily basis. The groundwater flow was analysed using hydrodynamic storage model and effective rainfall was estimated using SCS-CN method. The geographic digital information for terrain, soil, and landuse are constructed based on 1:5,000, 1:25,000 and 30m scales. The long-term hydro-environmental projections at 7 multipurpose dam basins are suggested in Figure 1. The hydro-environmental impacts are lowest in Juam. Sediment impact is expected highest in Soyang. Total-Phosphrous impact is relatively low in most areas, but highest in Imha.

4. CONCLUSIONS

Due to the temperature increase, the weather in the region of Korea peninsula is likely to get into the sub-tropical band. The projection by 2040 for precipitation and dam inflow gives 7.8~13.1% and 6.7~24.6% increase for all dams.

The projected streamflow into the 7 major reservoirs were decomposed into hydrologic components of direct runoff and baseflow and showed the increasing ratio of dam inflows will be greater than that of precipitation, which can be an noticeable alert for the water resources managers to build strategic plan for adapting to climate change.

The dams (Soyanggang and Chungju dmas) in Han river basin shows relatively higher increasing trend than the dams in the other regions, Nakdong river basin in particular. Overall increasing trends of dam inflows are greater than those of precipitation. As a result the availability of surface water resources can be expected to be improved, but, at the same time, the vulnerability against flood risk can be aggravated. However, the risk of water shortage will exist always due to the increase of weather variability.

The suggested streamflow projection can be used for predicting water quality at reservoirs and its downstream river channels. However, in order to predict sediment detachment from land surface with higher reliability will require finer temporal scales than daily scale.

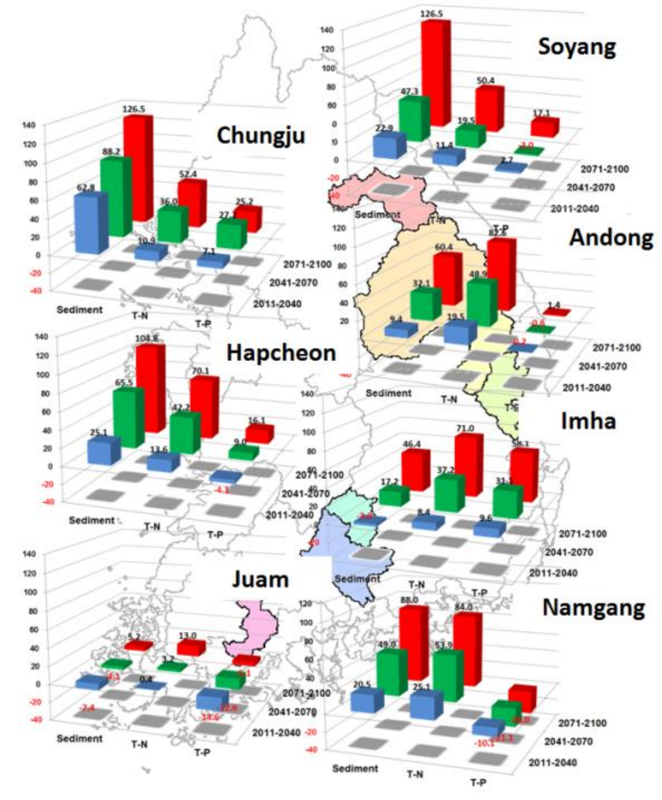

Figure 1: *Most meaningful example of a brilliant table with columns and lines filled with a minimum of quantitative information*

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