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Design and installation for Dam Monitoring Using Multi sensors: A Case Study at Sermo Dam, Yogyakarta Province, Indonesia

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3.1 GNSS CORS sensors at Base Station

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3.5 The sensor of Automatic Water Level Recorder (AWLR)

3.6 Installation of Communication System

4. RESULT AND DISCUSSION

5. CONCLUDING REMARKS

6. ACKNOWLEDGMENT

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PROBLEMS :

How to desaign and to install For monitoring using multi sensor at sermo dam

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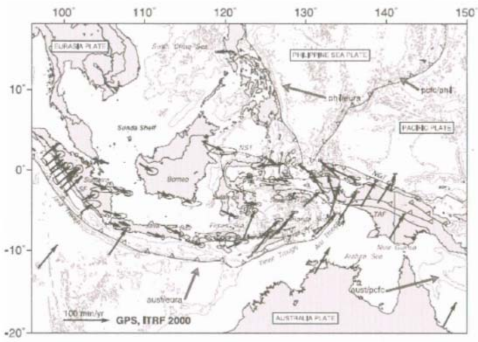

Fig.1. Indonesia Tectonic map with respect to ITRF 2000.0. Arraws are indicating horizontal displacements vector using GPS data in 1991 to 2001 (Bock et al, 2003).

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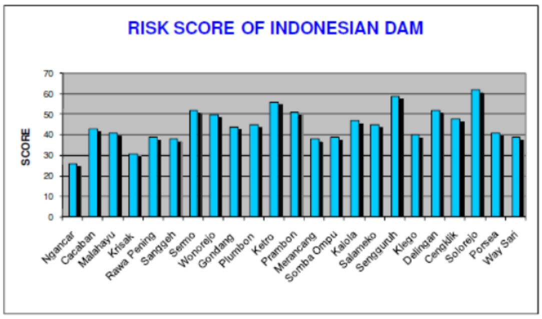
Table.1. Risk Assessment of Dams in Indonesia (Adzan dan Samekto, 2008)



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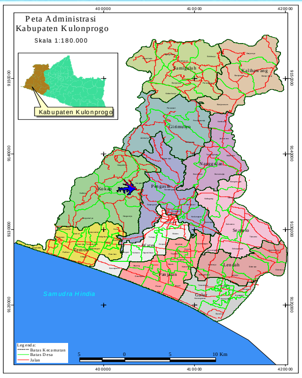

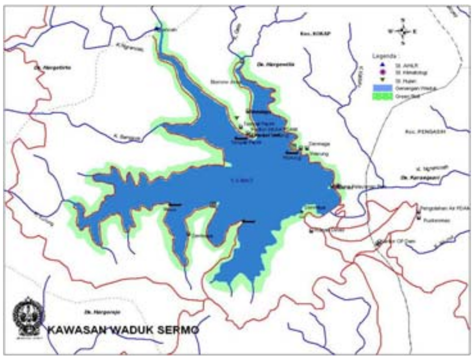

Fig.2. (a) Map of Sermo dam with dark blue color and its catchment area

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Fig.3. Sermo dam area at upstream

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Fig. 3. Sermo dam area at downstream area.

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Fig.3. Sermo dam area at upstream

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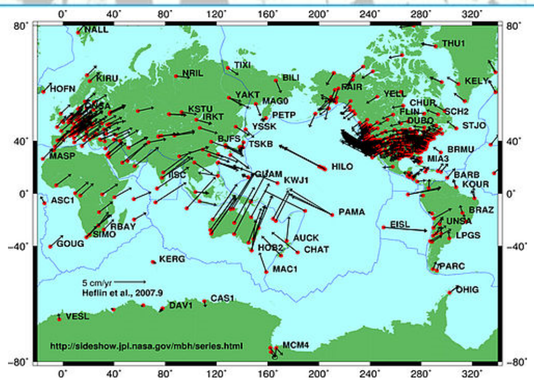

Fig.Plate motion based on Global Positioning System (GPS) satellite data from NASA JPL. The vectors show direction and magnitude of motion.

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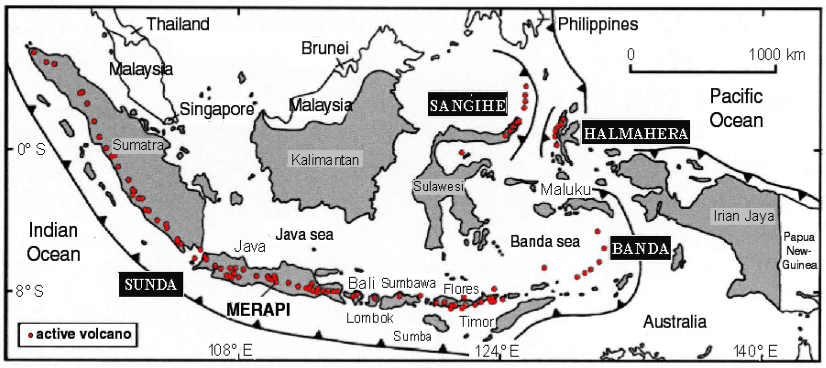

Fig. The Ring of Fire

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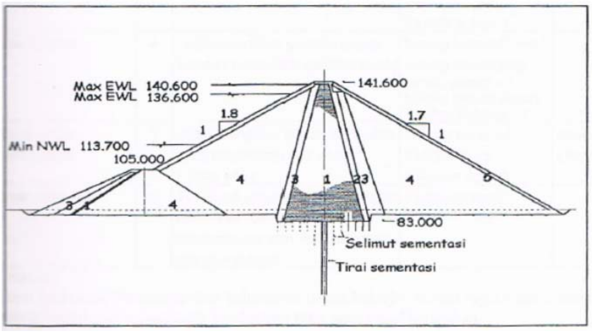

Fig.2. (a) Map of Sermo dam with dark blue color and (b) is cross section of Sermo dam

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Fig. Net Work Adjusment for Sermo Dam

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SERMO DAM MONITORING SYSTEM COMPONENTS

Component for Sermo dam monotoring system consists of remote area (in Sermo dam area) and computer center system. In the romete area, the components of the monitoring scheme consist of two main systems, there are :

a) Dam Deformation Monitoring System (DDMS) which includes a number of monitored object points on the dams and a network of

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local reference stations with respect to which displacements of the object points are to be determined.

b) On-site GNSS CORS System is the system for monitoring the stability of the area surrounding the reservoir (ridge lines) and for checking and updating positions of DDMS reference stations.

The computer center system consists of server and communication system from the remote area to computer center.

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DESIGN AND INSTALLATION SERMO DAM MONIRORING

The multi sensors in this research that permanently installed are 3D of RTS sensor, an array of permanently mounted prisms, two units of GNSS CORS sensors, Automatic Water Level Recording (AWLR) sensor, and Pan, Tilt, and Zoom digital IP Camera.

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GNSS CORS sensors at Base Station

The GNSS CORS sensors consits of Leica and Javad receiver. The Leica receiver has been installed at the first tower and the Javad receiver has been installed at the second tower.

The GNSS-CORS Receiver Main Monitoring Receiver Leica GRX1200+ and antenna CHOKE RING - GNSS Antenna with Dome, geodetic type as base station, at the first tower as SRM1 station (see Fig 4 (a)).

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Robotic Total Station and GNSS receiver has been housed in an "observation shelter". This observation shelter is located at DMU station (Fig. 4). The window has been constructed of four large glass panels joined in a faceted arrangement, similar to a control tower window at the airport. Windows has been 6 mm thick soda lime float glass. This glass has 91% transmission of light due to low iron content. The window has been installed at a slight angle. This is to prevent the theodolite line of sight perpendicular to the glass panel.

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(a) (b) (c)

Fig. 4. (a) Design and (b) the first tower for RTS and GNSS CORS at SRM1 station, (c) Setting up of Robotic Total Station

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(c) box for GNSS CORS receiver at SRM1 station.

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Fig. Coverage Ares of Monitoring Points

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Prism as Monitoring points

The survey of object points has been accomplished by taking radial shots in direct and reverse mode to all the object prisms. The RTS has been monitored horizontal and vertical directions, and slope distances. One of the reference stations as base station (presumably the most stable one) has been assigned as the main reference back sight for direction measurements as DMU area.

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The targeting of the total station to each prism is typically achieved by automatic target recognition. An Automatic Target Recognition (ATR) uses a charge-coupled device (CCD) camera mounted in the telescope of the total station to measure the return from a laser.

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(a)

(b)

Fig.5. (a) Crest of Sermo dam where points monitor (prisms with yellow color) have been installed

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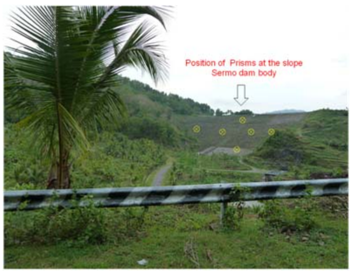

(a)

(b)

Fig.6. Target of monitoring with prism at slope of Sermo dam body

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GNSS CORS sensors at Back sight station

The second tower has been used for a GNSS CORS and one unit of prism as a back side monitoring as SRM2 station where the station is in upstream area of Sermo dam. Then at the back sight station has been placed for a GNSS CORS Javad Delta G3T GNSS Basic (GPS+Glonass) and Javad antenna GrAntG3T with Cone. The distance between the first and the second towers is about 2500 m.

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(a)

(b)

(c)

Fig.7. An antenna of the second GNSS CORS and a single of Prism as back sight (a) and (b); (c) box for GNSS CORS receiver at SRM2 station.

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Sensors of Tilt, Zoom digital IP Camera (CCTV)

Sensors of Tilt, Zoom digital IP Camera has been installed at Intake Sermo Dam. This sensor is ued to show video situation directly in upstream and downstream area.

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(a) (b) (c)

Fig. 8. (a) Is IP Camere presentation (CCTV), (b) and (c) are AWLR (Automatic Water Level Recording)

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The sensor of Automatic Water Level Recorder (AWLR)

The sensor of Automatic Water Level Recorder (AWLR) has been instaleed at intake Sermo dam. This sensor has been used to record the fluctuation of water in the upstream area.

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Installation of Communication System

The total stations will be linked to a computer system that will automatically and remotely control all functions.

The system has operated on a set time schedule and has automatically turn on at the correct time and start direction (horizontal and vertical) and distance measurement sets. The RTS has been programmed to collect a prescribed number of sets of angles at predetermined time intervals to achieve a preset level of accuracy.

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When collection of all the prescribed sets of the observation data will be completed, the data will be transmitted to the main office computer for its evaluation, processing and deformation analysis. The distribution of monitoring points surrounding Sermo dam body is plotted at Fig. 9. According to the final design, the DDM system has been installed a permanently mounted RTS at the first tower for monitoring 20 object targets (EDM prisms) mounted on a pillar type monuments.

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The 13 targets stations are at the crest of Sermo dam and 6 targets at the slope dam body at the downstream area and one prism at the back sight. The total station array has been installed to keep all distance measurements at 400 m or less. At least one reference back sight targets will be installed and included in the observation scheme at each robotic total station.

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Fig. 9. Installation of Multi Sensors at Sermo dam

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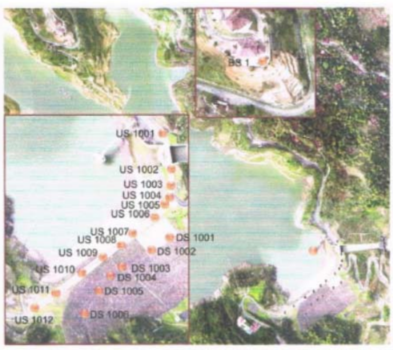

Fig. 9. Installation of prisms at Sermo dam where US: Upstream, DS : Down Stream

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Explanation of Multi Sensors

- = AWLR
- = Backsight station
- = GNSS Reference/Monitoring Station
- = Robotic Total station
- = Prisma
- = Wireless communication
- = IP cam

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RESULT AND DISCUSSION

This research monitoring system has been carried using complerized multi sensors. Data will be able to be logged over time to provide information regarding the effects of aging, earthquakes, erosion, storm events, and other variables on the overall health of the dam. With an effective monitoring program, these causes can be detected early and repaired or mitigated.

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Due to the number of factors involved (hydrological, geotechnical, structural, and power related), a wide variety of measurements are required for dams monitoring systems. Automated monitoring systems have become an important part of many dam maintenance programs. The systems will be flexible enough to measure the wide variety of sensors used in dam monitoring applications.

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Their low power requirements and rugged design allow them to operate unattended in harsh environments for long periods of time. Telemetry options provide real-time data and alarms to assist remote management system.
The GNSS CORS raw data have been computed in a two step process using the GAMIT (GPS Analysis Package Developed at MIT) and GLOBK software to define base station and back sight station.

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Sta.	Numerical Value					
SRM1	LAT. X(m) $_x$(mm) E (m)	-7° 46' 32,92201 -2.174.538,94742 5,130 403.787,192	LON. Y(m) $_y$(mm) N(m)	110° 7' 38, 71838 5.933.406,28999 4,158 9.140.387,265	h(m) Z(m) $_z$(mm)	231,43555 -862.922,86462 3,054
SRM2	LAT. X (m) $_x$(mm) E(m)	-7° 45' 58,03710 -2.173.483,16108 5,470 402.617,347	LON. Y(m) $_y$(mm) N(m)	110° 7' 00,59983 5.933.919,11690 4,030 9.141.456,224	h(m) Z(m) $_z$(mm)	202,71629 -861.850,60211 2,062

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CONCLUDING REMARKS

1. Safety and precise monitoring of Sermo dam deformations are the most important task to provide vital information on the stability and safety status.

2. GNSS technology will be extensively used for monitoring Sermo dam deformation,
The first tower has been installed a GNSS receiver and a Robotic Total Station. The second tower has been a GNSS receiver and 1 point target monitoring

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3. The installation of 20 points are along the center line of Sermo dam body (13 points), slope of Sermo dam body (6 points) and 1 point at the second tower are supposed to be enuogh for Sermo dam monitoring.

4. The installation of multi sensors (GNSS CORS, RTS, AWLR, and CCTV) to be integrated in one system will be a good automatic Sermo dam deformation monitoring system.

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ACKNOWLEDGMENT

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