Gravity change before and after the first water impoundment in Three Gorges Project

Sun Shaoan
Institute of seismology, CEA
gravity observation network in front region of the Three Gorges Project.
the earthquake gravity observation network in Three Gorges area

• Set up in 1982
• Study the relation between tectonic activities and earthquake
• monitoring the changes of regional gravity field changes, especially in some potential danger zones of earthquake in Fairy Mountain area
• ensure the safe operation of the Gezhouba project
the earthquake gravity observation network in Three Gorges area

• Only 30 station, many were placed at first-class water level points.

• The south and north observation lines linked as a circle at Yichang city and Xiangxi. Another one however, started from Yichang City and ends at Peace Brook, was abandoned at an early stage of the Three Gorges project for its disturbance to the project and bad condition of its observation stations along the line.
Reform of the gravity network

• 1998 the gravity network is reformed
• The scale is enlarged. expanded the original network to include Badong area, thus bringing the potential Xing Mountain-Badong danger zone of earthquake into supervision
• Repaired some already existed observation stations
• superposition with vertical deformation network of the head area
Theory gravity changes

• In 2003 first impoundment, water level is up to 135m.
• W. Hansheng ‘s theory calculation is $2000 \times 10^{-8} \text{ms}^{-2}$ at 135m, but it disappears 10km away from the dam.
• In order to monitor this kind of effect, two short gravity section were established. One of the lines traversed across the basin area with a span of 20km and 10 stations. Another line was set up alongside the south bank and is about 10km in length and has five observation stations.
Local gravity change before and after the water impoundment in Three Gorges dam region
Section observation and result

- 7 observations in all, 3 before water impoundment.
- The real line areas are where the gravity increases, while the broken line areas are where the gravity decreases.
- before June 11th 2003, gravity increases focus on regions near the reservoir.
- the maximum direct gravity effects resulted from water load is about $200 \times 10^{-8} \text{ms}^{-2}$ . the indirect gravity effects resulted from underground water infiltration and crustal deformation exist, but not as strong as direct effects
Section gravity changes

- after June 10th 2003, when the water impoundment finish, gravity increases obviously extend to the two sides, about 5 km away the bank.
- It shows indirect gravity effects enhanced.
Gravity effect and Vertical Deformation after impoundment in Three Gorges dam area
Vertical deformation and its gravity effect

• Vertical deformation’s effect on gravity is very small.
• the position and trend of range of the zero-line of vertical deformation in dam area tallies those of the gravity change.
• Need to be studied
Relative changes of gravity field in the foreside of the Three Gorges Reservoir

- b (2003.04-07)
- c (2003.07-10)
Regional gravity changes

• Fig.a illustrates features of gravity field change in head area before water impoundment, shows the gravity changes in April 2003 compared with those of October 2003;

• Figure 4b shows the gravity changes in July 2003 compared with those at the end of April. It shows the gravity increase result from water load. Maximum is at Xiangxi
Regional gravity changes

- Figure c reflects the characteristics of gravity change after the water level reaches 135m.
- If we contrast figure a with figure c, we can see that the two are quite different in shape.
- The position of positive district of abnormality transfers from the middle and south areas of the network before water impoundment to northern areas.
- The area from small to big and the trend of abnormal district from east-north to west-south
question

- is it a result of the natural adjustment of regional stress field or the force change of the crust’s medium resulted from water impoundment?
- If it has something to do with water impoundment, then what’s the relationship between the two? What’s the infiltration condition? If all these questions to be answered well, we need to do more research in a careful and delicate manner.
• The newly increased water load has evident effects on gravity field in dam area.
• 1. The characteristics of the water load are big influence and small range, and its effects decrease very fast with the increase of the distance from the center of the basin.
• 2. Gravity effect caused by vertical deformation does exist, but its degree and range are so limited that it can’t influence the space distribution shape of the overall gravity effect of the dam area. But it proves that lithosphere in dam area is stable after water impoundment.
• 3. The gravity effect resulted from underground water level change is only regional.
• 4. The gravity effect of rainfall has nothing to do with water impoundment, but its influence on high precise observation results is not neglectable.
• Besides, further study is needed to settle the problems of consistency between vertical deformation in northern dam area after water impoundment and the distribution of zero-line of gravity change, dissymmetry of gravity change, crustal deformation and underground water level change in south and north areas of the dam.