Seismicity and Reservoir Induced Crustal Motion Study around the Tehri Dam, India

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Abstract

The Tehri Dam is located in a seismotectonically active region in the Indian Himalayan belt. This 260.5 m high dam has a live water storage of $2615 \times 10^6$ m$^3$ and is capable of generating crustal deformation corresponding to water fluctuation. Filling of the reservoir started in October 2005. Seismic data around the dam between 2000 and 2010 shows that seismicity is corresponding to drawdown levels of the reservoir rather than to higher water levels. GPS data at twelve local benchmarks were collected from 2006 to 2008 during filling and drawdown reservoir levels. The velocity vectors show ground motion to be between $\sim$$0.69-1.50$ mm in the different filling-drawdown cycles with reference to the permanent station at Ghuttu. The motion appears to be inwards into the reservoir when the reservoir is filled and outwards when the reservoir is drained. This ground motion corresponds to elastic deformation and rebound due to effect of the oscillating water levels.

Key words: space geodesy, seismicity, reservoir induced ground motion, Tehri Dam (India).

1. INTRODUCTION

The Himalaya has given birth to several perennial rivers flowing from its glaciers into the plains. The rivers have a high potential for hydropower generation apart from providing drinking and irrigation water. The Tehri project is an irrigation and hydropower project, completed in the year 2005 and fill-
ing started immediately thereafter. The construction of the dam was associated with several concerns, especially following the magnitude $M_{6.8}$ Uttarkashi earthquake of 20 October 1991 (Fig. 1). The region experiences frequent seismicity. Subsequent to the Uttarkashi earthquake, the Chamoli earthquake, $M_{6.6}$, occurred on 29 March 1999 (Fig. 1). The concern for the safety of the dam in case of a major earthquake was mitigated with measures adopted for a safe dam structure. However, the concern for reservoir triggered seismicity (RTS) still instils speculations. The earliest example of RTS was reported from studies of induced earthquakes in the Lake Mead created by the 220 m high Hoover Arch Dam (Carder 1945). In India, the Shivajisagar Reservoir due to the Koyna Dam has been a significant example of persistent triggered seismicity since the last 50 years (Gupta 1992, Talwani 1997). The incremental stress under a two dimensional artificial lake was calculated by Gough (1969) and the implications of loading and unloading of a reservoir on seismic activity were discussed by Gough and Gough (1970a, b).

Fig. 1. Regional seismotectonics around the Tehri Dam, India. Seismicity is from the WIHG Garhwal Seismic Network. The area shown in this figure is beyond the area chosen for selection of seismic data for analysis. Figure also shows local faults around the Tehri region: (1) Dewal Tear, (2) Gadolia Tear, and (3) Marh Tear. Major tectonics features are shown after Valdiya (1980).