Comparison of Crack Movement Pattern Measured by Two Different Methods

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Abstract

Hydraulic structures are planned and built to behave safely during their design period. For understanding and to study the behaviour of concrete structure, instrumentation in the foundation and the body of structure is very much essential. With the continuous service, structures are developing cracks and joints due to concentration of stresses. These cracks and joints are required to be monitored, analysed and find out its effect of the safety of the structure. There is no standard method for selection of instrument location for measuring crack dimensions. However, instruments can be installed according to anticipation and assumptions of cracks during design. To study the variation of cracks in x, y and z directions, 2D and 3D crack monitors are usually installed across the cracks. Cracks are random discontinuities whereas joints are predetermined discontinuities. For crack/joints movement monitoring, usually, crack width and relative slip is measured. This paper discusses the comparison of the pattern of relative movement of crack in 2-dimensional (2D) and 3- dimensional (3D) directions by using 2D and 3D crack monitors data in Y-direction (across the crack) or closing and widening of crack in the powerhouse structure of 92 m high Rihand Dam, Uttar Pradesh, India.

Keywords: 2D: 2-Dimensional crack monitors; 3D: 3-Dimensional crack monitors; Relative movement; Powerhouse; Grouting

I. INTRODUCTION

Rihand dam is a 92 m high, 934 m long concrete gravity dam constructed during 1954-62 in the district Sonbhadra of Uttar Pradesh. A powerhouse is located at the downstream of the dam with an installed capacity of 300 MW. A reinforced concrete structure connects the toe of the dam with the powerhouse, and has the floors at the same level as in powerhouse. The transformers are placed on the top most floor of this framed structure. The load of the transformers is being transferred directly to the dam toe through columns. The penstock gallery is housed in this framed structure, which separates the powerhouse structure through a 25 mm joint.

Fig. 1: Location of Rihand Dam and Power House

II. PROBLEMS ENCOUNTERED IN POWER HOUSE

Within a few years of commissioning of project in 1962, cracks began to appear in the various portions of the dam and powerhouse. The following problems were observed in the powerhouse of dam:

- Tilting of generating shaft.
- Snapping of reinforcement and movement in penstock gallery frame columns.
- Tilting and movement of draft tube structure.
- Difficulty in operation of overhead gantry crane and draft tube crane.

The penstock gallery columns showing distress should be rehabilitated by epoxy grouting and steel jacketing. This was carried out in year 1985-87. However, cracks reappeared in the columns. The cracks were sealed and grouted with epoxy material in the year 2009-10.

Fig. 2: Location of both instruments on column no.6 at EL 622.00 ft.

III. INSTRUMENTATION BY CSMRS

Central Soil and Materials Research Station (CSMRS), New Delhi took up instrumentation work for monitoring of crack movement in 1986. Instrumentation has been done by CSMRS in two phases. In first phase, monitoring was done using Demec gauge (2D crack monitor) during 1986 -1998. In second phase, i.e. since 1998 onwards, crack monitors were installed for monitoring of crack movement. Long term monitoring of crack movement in 2 and 3 directions is being done using 3D crack monitor and digital vernier gauge (2D crack monitor) instruments. Both crack monitors are simple mechanical instruments through them crack movement can be measured. The crack movement in all three directions could be measured easily with the help of 3D crack monitor attached with the mechanical dial gauge and in two directions by 2D crack monitor with the digital vernier caliper. The cracks at 32 locations are being monitored using these instruments. Regular monitoring of crack movement is being continued using these instruments.

A. Description of Instruments

1) 2D Crack Monitor

This instrument is comprised of six hexagonal stainless steel pins. These pins are fixed as shown in fig.3. Pin A and D are fixed across the crack line and rests of pins are fixed both side of pin A and D at 60◦ angle. The nomenclatures of pins are clockwise from pin A. This crack monitor is used for monitoring of crack movement in 2 directions viz. along the crack (X-axis) i.e. the shear movement of the crack and across the crack (Y-axis) i.e. the opening and closing of the crack/joint with the help of digital vernier caliper.

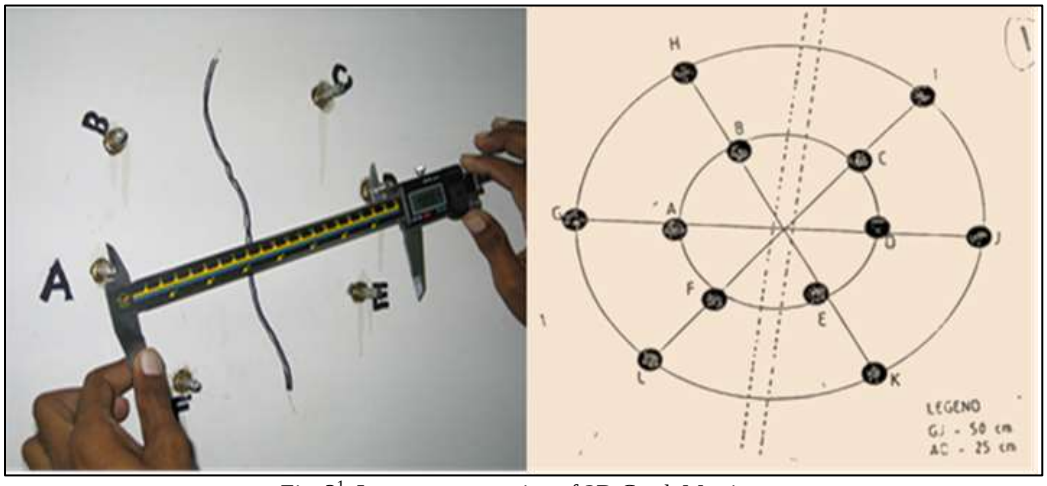

Fig. 3[1]: Layout presentation of 2D Crack Monitor

2) 3D Crack Monitor

This is capable of measuring crack movement in three mutually perpendicular directions as shown in Fig.4. X-axis measures the movement along the crack i.e. the shear movement of the crack. Y-axis measures the movement across the crack or perpendicular to the crack i.e. the opening and closing of the crack/joint. Z-axis measures the relative movement of the two walls of the crack/joint perpendicular to X and Y axes. Thus, the movement in all the three directions can be measured with the help of the 3D crack monitor.

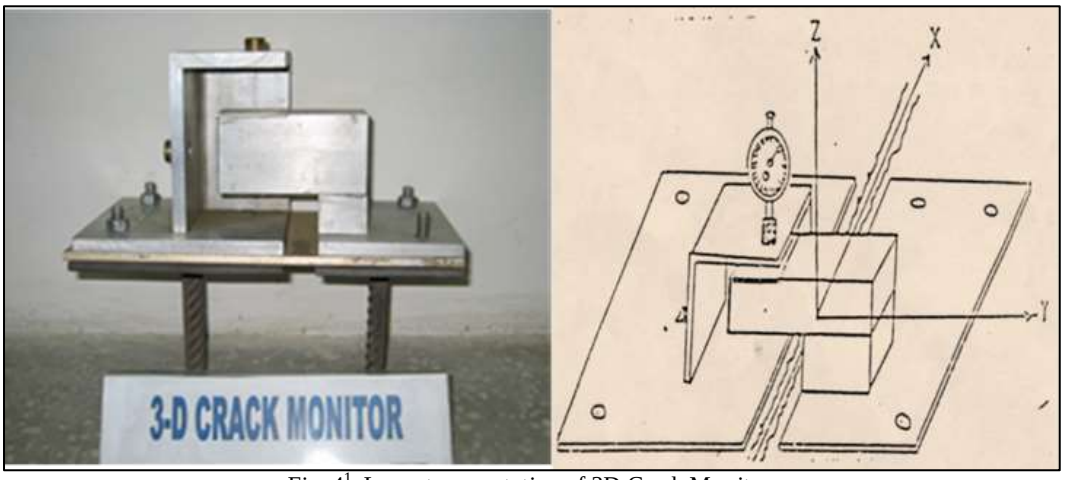

Fig. 4[1]: Layout presentation of 3D Crack Monitor

IV. DATA ANALYSIS

Figs.5 shows 3D crack movement monitoring (3D/6) pattern at column no. 6, EL: 622 feet in powerhouse. As shown in graph, crack movement pattern shows significant gradual movement of crack in Y direction (3.32 mm) since 06.03.2013 to 07.08.2018 (in about 5 years), while crack movement in Y direction is (3.29 mm) by using 2D crack monitor which is nearly same in this period of time. In Fig.5, zero reading of the relative movement for 3D/6 is 12.30 mm. However, in Fig.6 zero reading of the relative movement is as per actual.

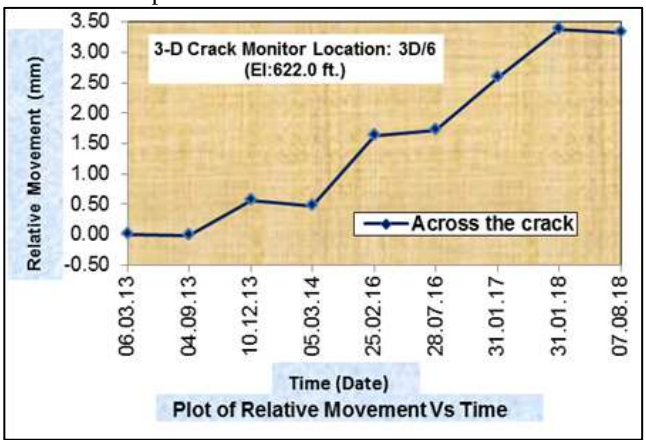

Fig. 5: Graphical pattern of 3D Crack Monitor

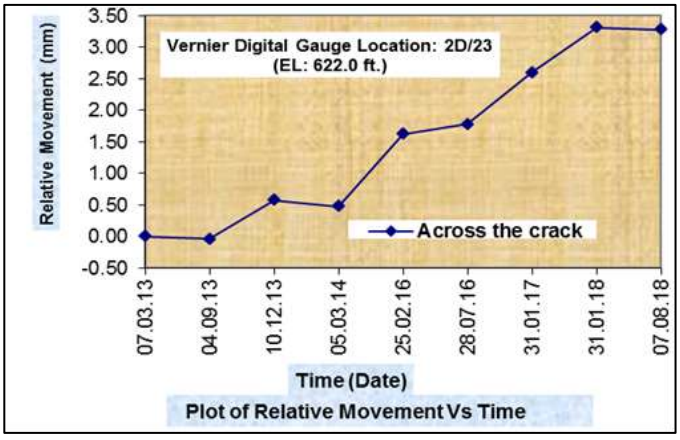

Fig. 6: Graphical pattern of 2D Crack Monitor

V. CONCLUSION

From Figs.5 and 6, it is observed that the relative movement of the crack increases with time. The pattern of crack movement measured by 2D and 3D crack monitors is almost same in Y direction (across the crack) or widening of crack. This shows that the result obtained by 2D crack monitor has been validated by the data measured by 3D crack monitor and vice versa. Therefore the measured data can be used for taking appropriate measure for rehabilitations of structure.

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