Project Title: Highwall mining design and development of norms for Indian conditions

Project No. GAP/MT/DST/AJP/91/2011-12

EXECUTIVE SUMMARY

The collaboration project “Highwall mining design and development of norms for Indian conditions” between the Commonwealth Scientific and Industrial Research Organization(CSIRO) of Australia and Central Institute of Mining and Fuel Research (CSIR-CIMFR) of India has been undertaken by scientists from both organisations under support from the Australian and Indian governments. The collaboration project comprises five key tasks, namely, (I) Literature review and collection of field data, (II) Development of a pillar strength evaluation method, (III) 3D numerical simulation and optimisation of web thickness and span stability, (IV) Parametric study and identification of important parameters, (V) Framing design norms and guidelines for Indian conditions based on the parametric study, and (VI) Technology transfer and reporting. All these tasks have been completed and the key results of this project are summarized below:

- Indian mining conditions are characterised by multiple seams with different parting thickness. Multi-seam interaction is a key challenge for highwall mining. Two end-user’s sites, Opencast Project-II (OCP-II) mine and Medapalli Opencast Project (MOCP) mine of Singareni Collieries Company Limited (SCCL) have been investigated in detail, where multiple seams with various interburden thicknesses, complex regional faults and stone band exist. In such a complex geological and geotechnical environment highwall mining design taking into account the unique Indian mining conditions is critically required.
- The most crucial part of highwall mine design is to estimate the strength of web pillars and load on web pillars more accurately. For web pillar strength estimation the modified CSIRCIMFR equation should be used. This approach has been successfully used in the MOCP and OCP-II mines of SCCL. Although there are several other pillar strength formulas which have been successfully used in highwall mining design in Australia and USA, the recommended formula has been shown to work well for the hard and high ash coal seams in India.
- For multi-seam mining it was found from numerical modelling that aligned pillars in different seams offer the maximum stability and hence this geometric layout is recommended. For those seams with < 3 m parting of weak strata, it is recommended to consider the combined height of the two seams including the parting in the empirical equation. In such cases, the sequence of mining should be top down to prevent the possibility of the continuous miner falling into the bottom seam.
- For Indian mining condition, it is recommended to utilise a minimum Factor of Safety (FoS) of 1.5 in multiple-seam scenario and a minimum FoS of 2.0 in those areas where important surface structures are to be protected from subsidence. When the web pillars are designed with a minimum FoS of 1.5, the requirement for wider barrier pillars may be waived. If slender web pillars with w/h ratio < 1.0 or with FoS less than 1.5 are used, it is necessary to leave properly designed barrier pillars to ensure stability after a specific number of web cuts. The width and intervals of such barrier pillars need to be determined using well calibrated numerical simulation.
- Navigation of the highwall mining entries is critical to ensure that the designed pillar width is achieved in actual mining operations. Poor navigation in the past had led to entry collapse and the burial of a continuous miner in Australia. It is therefore necessary that the highwall mining system employed should have an accurate navigation system and the mining operators should take extreme care to maintain the positioning of the highwall entries over the entire length.

- Highwall mining entry span stability is a critical factor for the success or failure of highwall mining operations. Pits with weak clay or shale in the immediate roof in India have experienced frequent roof falls which caused delays and early termination of the entries. It is mandatory to assess the roof span stability using empirical methods such as RMR and also preferably using numerical modelling techniques. This is taking into account that the RMR method is commonly used in Indian mines and the input data are readily available. It is also recommended that a preliminary assessment be done using the simple Laminated Span Failure Model developed by CSIRO.
- Highwall stability is critically important for personnel safety during highwall mining, and in most cases it is controlled by geological structures such as faults, joints, and other discontinuities. A framework of mapping the geological structures remotely has been developed, which is based on the SiroVision and SiroModel developed by CSIRO. A case study of using this technology in an end-user's pit has been carried out and presented in this report, which demonstrates the effectiveness of this technology.
- For large scale highwall stability, several pit scale modelling investigations and parametric sensitivity studies have been conducted. In India, the slope of final highwalls is kept generally flat at about 40° to 45° but when trench highwall mining is practiced slope angle is usually steeper and in the range of 70° to 80°. Any mistake in design of such steep slope may jeopardize mining safety and productivity. It has been demonstrated in this project that the assessment of large scale highwall slope stability needs to incorporate the proposed multiple/single seam extractions through numerical modelling. It is also recommended that good blasting practice such as pre-splitting should be considered when forming the highwall face in order to minimise the blast damage.

Overall the project team has completed all the pre-defined tasks and successfully developed a general guideline for highwall mining design for Indian mining conditions. The guideline is already being implemented in Indian highwall mining operations with initial success. It is envisaged that the guideline, which combined the past experience in Australia and USA with India's specific mining conditions, will significantly help the successful implementation and expansion of highwall mining in India.