A hybrid of GNSS remote sensing and ground-based laser technology for geo-referenced surveying in mining

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Rapid, precise and frugal surveying is a strategic factor in the present mechanized mining environment owing to rapid surface profile transformation in a short period. Determination of global coordinates with high accuracy using the satellite-based global navigation satellite system (GNSS) has been studied in the mining arena and is gradually becoming an essential component. A case study of Khanak Stone Mine, Haryana, India, is discussed here, highlighting the combination of GNSS system and terrestrial laser scanner for the preparation of a surface profile of a rugged terrain with the key objective to determine the precise *in situ* rock excavation in periodical phases. The actual tonnage of rock produced/transported from the mine has been calculated by determining the *in situ* density and bulk density in the laboratory. The study reveals that this survey of approach is apt to achieve quality plan and to obtain the goal of actual tonnage of rocks excavated.

Keywords: Georeferenced surveying, hybrid technology, laser scanner, remote sensing, Stone Mine.

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tion Ltd (HSIIDC), India, to determine the volume of rock excavation by laser technology. A combination of global navigation satellite system (GNSS), total station and LiDAR-based terrestrial laser scanner (TLS) was used to survey intricate terrain to obtain accurate field data.

Modern survey instrumentation: a backdrop

GNSS

GNSS, an outgrowth of the differential global positioning system (DGPS), bridges the gap in calculating the global coordinates of a point at the surface of the Earth by trilateration with high precision. It uses the core satellite constellations, i.e. the United States' Global Positioning System (GPS) and the Russian Federation's GLObal NAvigation Satellite System (GLONASS), the European Satellite Navigation System (GALILEO) and China's COMPASS Bei-Dou, India's Regional Navigation Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS) and augmentation systems. Satellite navigation