Rainfall Monitoring & Proposed Warning System

Residential Briefing

Berryhill Quarry

November 2020

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CONTROL SHEET

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1.0 Introduction

Fairhurst were commissioned by Mansfield District Council (MDC) to design a rainfall monitoring and trigger warning system at the site of the former Berry Hill Quarry. This work was undertaken in response to a mass slope failure that occurred on site on the 7th November 2019 after a prolonged period of heavy rainfall.

Fairhurst have designed and tendered stabilisation measures to reduce the risk associated with mass failure at the site. However, owing to land disputes and ongoing discussions with residents, adoption of the stabilisation measures have been delayed significantly. As set out below, the mechanism of failure which drove the previous mass failure was considered to be a result of prolonged rainfall over a period of time, followed by an intensive rainfall event leading a mass failure of soil and rock at Unit 6 of Berry Hill Quarry.

Therefore, as the works have been delayed and we enter into winter period where similar rainfall patterns may emerge, it was considered that a system which allows monitoring of the rainfall and predicted weather events is required in an attempt to categorise the risk of another failure and, where necessary or reasonably possible, take pre-emptive action to reduce risk to residents and their properties at the toe of the quarry. The measures set out in this technical note will not reduce the likelihood of failure and cannot guarantee the prediction of a large mass failure.

2.0 Background

The former Berry Hill Quarry is located in SW Mansfield. The quarry was formed in sandstone with face heights ranging from 10 to 25m and with slope angles from less than 45 degrees to locally close to vertical in the SW corner of the quarry.

The sandstone faces comprise interbedded layers of weak locally moderately strong sandstone and weak to very weak, locally totally weathered sandstone. The upper part of the faces in many locations has weathered to a residual soil and takes the form of a poorly cemented silty sand. Additionally above the quarry faces there appear to be bunds that were formed during the operation of the quarry and these are considered to likely comprise overburden stripped from the surface of the quarry site prior to it being worked. In 1998 permission was granted for a residential development to be constructed in the former quarry floor, and currently occupies the site.

3.0 2019 Failure

On the afternoon of Thursday 7th November 2019, a large failure mass detached from part of the southern former quarry wall. The large failure was a composite soil and rock slip that was considered to be a result of unusually high rainfall. The ground was saturated owing to several rainfall events in the preceding month, and this increase in saturation would have led to an increase in porewater pressure and movement or creep in the wall of the quarry. The initial movement would have created tension cracks, allowing deeper and more rapid penetration of water into the soil mass and underlying weathered and weak rock. This process would have continued until the strength of the remaining weak rock mass below could no longer sustain the combination of the weight of the saturated soil, rock and water pressure, resulting in the large failure.

Once mobilised the failed material broke up and became a semi-fluidised mass with the slab of vegetation and trees remaining on top of the mass and being pushed towards to the front of the slip. The failure occurred to the rear of properties 42, 44 and 46 Bank End Close with falling debris crossing an exclusion zone between residential properties and the quarry toe, breaking through the rear garden fences and coming to rest between half and two thirds of the way into the rear gardens, approaching the rear of the residential houses. A predominant tree that was previously at the crest of the slope came down with the failure and toppled over coming to rest against the rear of No 42 Bank End Close house. The only damage sustained to the houses involved was a broken pane of glass in one of the windows of No 42, caused by a branch of the fallen tree. Other damage on the properties included fence lines, garden sheds etc., and the mass of soil / debris within the gardens themselves.

Other failure mechanisms at Berry Hill Quarry have been identified historically and observed to be ongoing, including weathering, ravelling and small block failure. This monitoring and warning system seeks to reduce the risk associated with potential large mass failure as a result of rainfall inundation/soil saturation only.

4.0 Rainfall Analysis Prior to Event

A detailed analysis of rainfall conditions has been undertaken to develop a rainfall monitoring programme with an aim of identifying future combinations of rainfall events that could lead to further failures of the quarry wall as described above. Fifteen minute interval rainfall data from 2018 to 2020 from a local weather station has been reviewed and analysed. It identified key rainfall factors that are considered to have led to the failure, including high cumulative rainfall in the weeks leading up to the failure, with then further intense rainfall in the preceding week, which included an issue of an amber rainfall weather warning by the met office in the hours before the failure event.

Analysis of the rainfall from the previous c. 2 years confirm no such complete combination of the above rainfall factors, other than associated with the failure event.

5.0 Rainfall Monitoring and Trigger System

Based on the above understanding of rainfall factors which may lead to a similar event, Fairhurst will monitor the rainfall data and weather warnings issued by the government and their regulators. A conservative trigger system has been developed which allows early warning of when rainfalls totals are predicted to potentially meet the previous levels, using cumulative 6 weekly and weekly data. Additionally, weather warnings are being automatically issued to MDC and will be used to supplement the rainfall review.

Fairhurst have developed a risk matrix which quantitatively assesses the potential level of risk depending on the number of rainfall and weather warning factors that occur. The matrix then categorises the level of risk, which will lead to three potential scenarios:

- Scenario 1 – Fairhurst will notify MDC of the increased risk and Fairhurst will monitor the situation until the triggers change;
- Scenario 2 – Fairhurst will notify MDC of increased risk, and MDC must notify residents of potential imminent evacuation;
- Scenario 3 – Fairhurst will notify MDC of increased risk and MDC must evacuate residents immediately.

The proposed warning system is based purely upon rainfall events that have led to the single mass failure on site, and is therefore limited to one type of failure event. Fairhurst will continue to undertake site inspections with regards to other failure mechanisms and notify MDC of any significant changes on site. The trigger warning system has been adopted as an interim monitoring system in an attempt to reduce risk to residents during the winter months while permanent stabilisation works are not yet in place. The aforementioned system can only aid prediction of such events and cannot guarantee that an event will not occur that has not been identified. It is considered imperative that the stabilisation works are implemented as soon as possible to reduce the level of risk to acceptable levels.

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