5.4 CONCLUSIONS

The study on cable joint failures, its causes and impact on availability and profitability has shed some light for future works. The findings are to some extent conclusive for certain areas as mentioned in the summary. Future research should continue to study the other areas which are not conclusive.

The success of the recommendation proposed depends on the commitments and involvement of all parties concerned and the diligence of jointers and supervisors to improve the quality in daily work.

New tools should be developed to manage data effectively and productively. With the rapid developments of IT, the tools should readily be available in the market.

These proposals and alternatives are not exhaustive. It can be used to pave the way for future improvements in cable joint failures works.

5.1.2 Lack of Knowledge and Skills on New Jointing Techniques

Lack of knowledge and skills in the part of the jointers will lead to substandard joints. Once confronted in situations where he must do the joint, these jointers may do the joints based on their standard practice of jointing techniques. The joints made may not meet the required specifications. The joint may fail immediately.

There are instances of failed cable joints sent for post-mortem which are easily observable that the joints were not done in accordance to the specifications. Components that should be used for injecting pressure were missing. Some of the joints analysed use wrong size of cable jointing materials.

5.2 RECOMMENDATIONS

As discussed in the earlier section, two factors that cause cable joint failures. In this section, recommendations are forwarded as alternatives to solve the problems of cable joint failures due to the two factors.

5.2.1 Ground Reinforcement

Most of the failures on soft or wet grounds are due to movements of heavy vehicles. These movements of heavy vehicles cause vibrations and movements of the soil due to the weakening of the soil structure. The real problem is

movements of the soil due to its weak structure. To overcome this problem, the soil needs to be reinforced. This can be done by reinforcing the joint pit using simple wood base piling or by concrete structure. The strength needs to be calculated to ensure economic solution with optimum protection.

5.2.2 Knowledge and Skills Audit

Lack of knowledge and skills can only be overcomed by training or coaching.

Training for new aspiring jointers is well structured. The problem may be with experienced jointers. They may form their standard practice and performed new jointing techniques based on their perceived standard practice.

It is proposed that district appoints an experience jointer to be trained in refresher courses on cable jointing techniques. The jointer will act as the standard knowledge and skills reference in the district. Knowledge and skills audit should be conducted to all jointers in the district yearly by the referenced jointer concerned.

All audit activities should be recorded in term of date of audit, name of jointer, age, experience, place of the audit and result of the audit.

5.2.3 Jointing Materials

Another observation made during the interview is that too many brands of jointing materials are introduced.

It is quite difficult to master all techniques for all brand of jointing materials. The probable solution is to limit the number of jointing materials used in TNB to two or three brands only.

New jointing technique or new brand of jointing materials introduced should be gradual in nature. All jointers should be trained first before they are allowed to perform joint using the new techniques or new brand of jointing materials. The first joint made using new techniques or new brand of jointing materials should be pressure tested before allowing the jointer to continue using the new technique or new brand of jointing materials. This is to minimise repeated failures due to inappropriate or poor workmanship.

5.2.4 Data Management of Cable Joints

In the summary of the findings, unknown response score higher in almost all the response needed. This is partly due to poor data management.

5.2.4.1 Data Recording

It is proposed that the mode of data recording for cables and cable joints be reviewed to facilitate future works. Data on cable and cable joints or any other feeder components should be recorded from the day the components are being constructed or put into service. Example of data that are critical for future works are conditions of environment during the joint, loading, type of joint, date of joint made, commissioning date, moisture test on cable before jointing, failure date, feeder, manhole, manufacturer, date of manufacture, reasons for failures as determined from a laboratory analyst, cable section replaced, location of failure, joint configuration and type, cable configuration and hipot test [13].

5.2.4.2 Computerisation of Data Management

The study on failure prediction of underground distribution feeder cables [12], extract data from the mainframe. Some of the data is mentioned in subsection 5.3.1 above. Computerisation of data to some extent makes it possible for accurate and timely retrieval of data that is crucial for decision making process.

5.2.5 Training

District's representative should be trained and encouraged to participate in the decision process of the proposed data acquisition system as in subsection 5.2.4. The people who are recording the data should know the use of the data collected for accurate and timely data. The dissemination of this information is best done through training. All personnel involved should be trained before introducing the system.

5.2.6 The Human Touch

The result of post-mortems and interviews indicates that majority of the failed cable joints opened up were due to poor workmanship. We should learn from the Illumination Studies at the Huge Hawthorne Works of the Western Electric Company outside of Chicago in 1924 [15]. The studies show the complexity of human variable.

Jointers need positive reinforcement and recognition. Identifying cable joints to the jointers may give a sense of attention needed by them. This can be done by tagging the joints with data such as name of the jointer, date and the weather at the time the joint was made. The approach to this system should be strategised in such a way that jointers do not perceive it as a ploy by management to take disciplinary action. It should be seen by jointers as creating ownership of quality

joints and sense of competitiveness among jointers..

5.3 FUTURE WORKS

There are questions to be answered that this study cannot address due to lack of accurate data. The high returns of unknown response make this study inconclusive in certain areas such causes other than movements of heavy vehicles and lack of knowledge and skills issues.

Recommendation on data management needs to be seriously looked into for future works. It is the basis for further study on the subject as well as other components of distribution feeder [12]. Other utilities have gone ahead with predictions of the probabilities of failures used for work safety as well as economic considerations [12], [13].

The life of the components of distribution feeder needs to be monitored. Condition monitoring should be adopted for better understanding of components' pattern connected to the distribution feeder. The study should be on going.

A laboratory with up to date equipment such as x-ray and partial discharge detector should be set up to test faulty joints. These equipments can also be used to monitor joints in service.

5.0 SUMMARY, FURTHER WORKS AND CONCLUSIONS

5.1 SUMMARY OF THE STUDY

Two distinct factors can cause cable joint failures surfaced from the study. These two factors are:

- movements of heavy vehicles on soft ground
- lack of knowledge and skills on new jointing technique

5.1.1 Movements of Heavy Vehicles

Movements of heavy vehicles and excavation on soft and wet ground are one of the causes of cable joint failures buried in those conditions. Cross referencing with the two factors make it clear that they are related, Table 10 Appendix B.

The movements of heavy vehicle along the cable route cause direct cable movement or continuous vibration to the cable. It is transmitted to the cable joints. Cable movement causes tension to the cable and cable joints which lead the joints to degrade in term of its mechanical strength which in turn cause weak spot and heating may take place [7], [13]. Eventually the cable joints will fail.