

4.4 IMPACT OF CABLE JOINT FAILURES ON AVAILABILITY AND PROFITABILITY

Cable joint failures result in unavailability of supply for a period depending on the response of the staff on standby and the system. The average time to restore supply after such failure is two hours for a ring and firm circuit. However, for a weak ring or radial feeder, the average restoration time is 6 hours. Overall average disruption time can be considered as 4 hours.

In the 'Lesen Kepada Tenaga Nasional', [14] it is stipulated that TNB should restore 50 % of the supply after two hours and 100 % restoration after 4 hours. On average, TNB manages to meet the licence requirements by restoring supply to the affected areas within the stipulated period. There are some instances where these interruptions of electricity supply can be restored within one hour, and on the extreme case it may take more than six hours.

The above paragraph tries to highlight TNB corporate responsibility concerning interruption of supply. However, the vision should be zero interruptions of electricity supply.

Sample calculation of the costs of failure is as in Appendix C.

construction, termination joints are less prone to failures.

4.1.2 Jointing Technique and Age of Failed Cable Joint

Number of breakdowns recorded based on jointing techniques is as Table 3. The highest failures recorded, 37.7 %, were for unknown response. It is quite amazing that technique of jointing which can easily be identified by the construction of the joints were recorded as unknown response. Further analysis on this matter needs to be pursued.

Resin filled joints are the next highest failures at 123 or 28.5 % of the total failures recorded. Compound joint being the conventional joint is commendable at 57 failures or 13.2 %. The compound joint is commonly used in TNB for more than 50 years. It was phased out slowly with the introduction of heat shrinkable material for termination joint in 1977 [9] and straight through joint in 1982 [10].

It is interesting to see that newer jointing techniques which are supposed to make jointing easier, faster and reliable recorded a short life span. Cross tabulation between the age of joints and the techniques used for the cable joint is as in Table 5 Appendix B. Based on length of service 36.8 % of the total compound joint failures fail after 10 years, 36.8 % between 5 - 10 years, 8.8 % between 4 - 5 years, 1.8 % between 6 - 12 month and the remainders are unknown.

Resin filled joints were 85.4 % recorded as unknown age. Resin joint is only introduced in recent years.

Another interesting fact is that half of the heat shrinkable material joints were recorded as unknown age. The rest of the failures are well distributed between 4 - 10 years old. Small numbers of failures were recorded in the early age of service.

The age factor recorded as unknown for both the new jointing techniques, heat shrink and resin joint are 140 failures (34.5 %). The total age factor recorded as unknown is 299 failures (69.2 %).

Commissioning date of the failed joints were recorded as 35 cases known and 397 unknown, Table 6 (see Appendix B). The ages of the failed joint were recorded 299 as unknown in the age column, Table 8 of Appendix B.

4.1.3 Joints Done on Various Types of Cables

Table 8 of Appendix B show the frequency of joint done on various types of cable. As expected, transition joint, joint made to two types of cable, for example PILC cable joint to XLPE cable recorded a small number of failures. This may not reflect the true story as this type of joint is rare and needs special skills and techniques to avoid deteriorating the properties of both cable if not done properly [7], [10].

4.1.4 Ground Conditions of the Failed Cable Joints

The districts are asked to record the ground condition of the failed joint. Main factors that make cable joints fail are mechanical failure and moisture seepage [7]. Ground conditions affect the stability around it. Soft and wet grounds are not strong compared with dry or normal ground.

Soft ground account for 97 failures (22.5 %) and failures due to wet ground were recorded to be 9.7 % or 42 failures Table 9 (Appendix B). Ground movements cause the cable to move which in turn cause tension and loading along the cable. Joints being the weakest mechanical link along the cable will be affected first. The unknown factor seems to be the leading score of 174 failures.

Cross tabulating between ground conditions and probable cause of failures are as Table 10 (see Appendix B). Districts record unknown cause and unknown ground conditions for 151 of the 432 cable failures, that is 35 %. Probable cause of difficulty in making the joint occurs in wet and soft ground. The environment of wet and muddy surrounding may make the jointer uncomfortable and hence low quality job.

4.1.5 Probable cause of cable joint failures

The result of probable cause of cable joint failures is as Table 11 (see Appendix B). There are 219 cable joint failures due to unknown causes representing 50.7

% . Heavy machinery movement is next highest score (80) of probable cause of failures representing 18.5 % of the total failures. The other two causes with about 6 % are due to excavation and moisture.

4.1.6 Loading of Cable Joints

The loading of the cable joints that fail shows that the unknown factor is the highest with 311 representing 72 % of the total sample. Some of the cable joints failed almost immediately (0 - 19 % loading) which basically are not carrying its potential capacity. Joints should be able to carry the full load capacity of the cable used.

Out of the 432 failures, only 16 failures are carrying higher than 80 % load, see Table 12 Appendix B.

4.2 RESULT OF POST-MORTEM

Hard data on the result of the post-mortem is not available. Personal interviews and discussion with the staff doing the post-mortem were conducted to find out the root cause of the problem. Some of the failed joints sent for post-mortem are in bad shape. These conditions make it difficult or impossible for the samples to be analysed.

Post-mortem for compound and resin joint are difficult. Compound and resin

harden with time. So, it is difficult to be opened and analysed. Traces of imperfection or flash over in most cases could not be traced.

Heat shrink cable joints are easier to be opened and analysed for defects. The material used do not hardened with time.

Out of about 50 joints opened, 40 are of resin material and 10 are heat shrinkable material. Majority of the joints opened show defect in workmanship. This may be due to lack of skills and knowledge of the new jointing techniques. Jointers find it difficult to master too many jointing techniques introduced.

4.3 SUMMARY OF THE FINDINGS

The data under study are biased towards the basic response of unknown. Data on critical factors such as ground condition, loading, commissioning date, age and probable causes of failures were recorded as unknown. The researcher finds it difficult to analyse such data as it may lead to wrong conclusions.

It is good to note that the average failure rate for 10 of the 11 districts is 4.5 per 100 km for the period of 8 months. One of the districts recorded a rate of 27 per 100 km for the period of 8 months. This rate is high compared to the figure of USA and UK [7]. The average rate of failures is 12 per 100 km per year [7].

4.3.1 Unknown response

From the results obtained, with simple pattern method, it is clearly seen that the unknown response is exceptionally high for the factors listed below:

Question	% of unknown response
Type of joints used	37.7
Cable joints commissioning date	91.9
Age of the joint	69.2
Ground conditions	40.3
Name of jointer performing the joints	70.4
Employer of jointer	43.8
Probable causes of cable joint failures	50.7
Loading experienced by joints prior to fault	72.0

All the factors above except probable causes of failures, is simple recording of data during jointing and failure time. For a more conclusive result, data should be captured and maintained to be used for further analysis.

The area of probable causes of failures needs some skills in analysing, sound jointing skills and sound technical knowledge of the construction of all types of

joints. The response of unknown may indicate that the persons who analyse the cable joints do not possess the prerequisite skills and knowledge of analysing it. Probable causes with apparent physical traces such as exposed, movement of heavy machinery and excavation are easily identifiable.

4.3.2 Ground Conditions and Probable Cause(s) of Failures

Cross referencing ground condition and probable cause of failures shows that failure of joints caused by excavation in soft ground condition are 51.9 %. These can be attributed to the easiness of excavating in soft ground condition and the tendency of the cable to be pulled is greater.

Another interesting aspect is that failures due to the movement of heavy machinery occurs mainly in soft and wet ground, and ground movement that is 96.3 %. This can be implied that this type of ground is susceptible to heavy vehicle movement.

Cable joint failures due to moisture were recorded to be 28.6 % in sandy ground, an average of 3 % on other ground conditions and 53.6 % unknown ground condition.

4.0 RESULT OF SURVEY

4.1 SECONDARY DATA - CABLE JOINT FAILURES REPORT

There are 432 breakdowns recorded during January 1995 to August 1995 for the 11 districts listed in term of their sizes (see Table 1, Appendix B).

The number of breakdowns recorded are 148 failures (72.0 %) for big districts, 29 cable joint failures (6.7 %) for medium districts, and 92 failures (21.3%) for small districts within the window period of eight month.

It is quite interesting to see that the medium district experiences lower cable joint failures as compared to the small district. However, based on the ratio of cable joint failures and length of cables laid, the result is comparable.

4.1.1 Cable Joint Failures by Location

Towns near the coastal areas (one big and two medium districts) recorded 114 failures compared to 318 failures recorded in districts located in mainland, Table 2 (Appendix B). The result shows that there is a difference in the number of cable joint failures for districts along the coastal area as compared to those in the mainland. This may be due to the fact that half of the cables laid in coastal area are low voltage cables which are normally very short and the joints performed are normally termination joints. From the result of cable joint failures based on