A DISCUSSION ON THE EFFECT OF GOVERNMENT SUPPORT FOR NETWORK RELIABILITY

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1. INTRODUCTION

It is important to keep the highway network highly reliable after a major disaster. If a serious earthquake happens in some regions and many links are collapsed, the question which link should be selected to reconstruct firstly to improve the increase of network reliability effectively is important. There are many nonmaterial factors on this question such as the damage level of some link, the number of injury people near some link, refugees' confidence and volunteers' devotion and so on although the investment is very important to improve the network reliability most of the time, and those nonmaterial factors can replace investment sometimes. Chinese government will provide the different resource to all of disaster regions according to the area of the disaster region, the damage level of the disaster region and the number of disaster victims and other factors. And government can play an important role in improving the reliability of the highway network by providing more nonmaterial support such as the labor force and the confiscation of land. But the effect of government support was ignored in current indices such as probability importance and criticality importance for a long time. So we would like to discuss the effect of government support in order to improve the increasing of the network reliability mostly.

2. THE MODEL OF THE EFFECT OF GOVERNMENT SUPPORT FOR RELIABILITY

As mentioned in Introduction, government support is an important factor for increasing the network reliability. Government support includes material support and nonmaterial support, and the material support is considered as investment usually, the nonmaterial support includes many aspects such as technology support and volunteers and so on. We try to give the following assumptions under Chinese factual situation in order to discuss the effect of government support on the network reliability and the nonmaterial support is discussed mainly.

(1) The support given by government is limited.

(2) If government gives more support to increase the reliability of links after a disaster, more nonmaterial factors can be used to reconstruct the collapsed links such as more soldiers being called up as the labor force and more land being confiscated since the ownership of the land only belong to the State according to Chinese laws. If government gives more support, there are more people who wish to contribute to reconstruct the collapsed links as volunteers based on government's appeal.

(3) If government gives support, cost of the reliability which will reach 1.0 does not tend to infinity. On the contrary, if government does not give any support, the cost of the reliability which will reach 1.0 tends to infinity.

(4) When the reliability equals zero, the original cost dose not equal zero because of those basic work for increasing the link reliability.

$$\frac{dC_a}{dr_a} = \alpha e^{\frac{r_a}{\beta_a}} \quad \text{(Eq.1)}$$

$$C_a = \alpha\beta_a e^{\frac{r_a}{\beta_a}} + C_0 \quad \text{(Eq.2)}$$

$$\delta C_a = \alpha\beta_a e^{\frac{r_a+\Delta r_a}{\beta_a}} - \alpha\beta_a e^{\frac{r_a}{\beta_a}} = \alpha\beta_a e^{\frac{r_a}{\beta_a}}(e^{\frac{\Delta r_a}{\beta_a}} - 1) \quad \text{(Eq.3)}$$

$$C_{increase} = \sum_{a=1}^{N} \delta C_a \quad \text{(Eq.4)}$$

Base on those assumptions, the relationship between the increase in cost and the increase in link reliability can be found out.

If the cost of a link with reliability r_a is C_a, one can allow for the cost of improving link reliability increasing as the link reliability increases by assuming the marginal cost dC_a of a marginal improvement dr_a in the link reliability is given by Eq.1.

Keyword Network Reliability, Government Support, Cost-reliability Function, Disaster Prevention
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α is a positive constant, and $\frac{dC_a}{dr_a} = \alpha$ when r_a equals zero, and β_a which stands for the effect of government support for link a in network reliability is a non-negative constant. Because it means that government doesn't give support when β_a equals zero, $\frac{dC_a}{dr_a}$ tends to infinity. The $\delta\beta$ which means the summation of the support of those links which reliability is increased after getting government support is named the effective support. $\delta R / \delta\beta$ can reflect the efficiency of government support.

The cost-reliability function can be given by the Eq.2. Because of the assumption (4), C_0 is the value of $C_a - \alpha\beta_a$ when r_a equals zero. If the reliability of link a is to be increased by δr_a from r_a to $r_a + \Delta r_a$, then the cost follows as the Eq.3. If there are N links in the network, then the total increasing cost of the network is shown as Eq.4.

3. THE SIMULATION ON THE EFFECT OF GOVERNMENT SUPPORT

Three kinds of simple network including series network, parallel network and simple bridge network were discussed. The effect of government support on network reliability would be discussed by simulation when some links of the whole network have changed under the same funds. In fact, the effect of government support on network reliability can be simulated by optimization methods, so we used the software LINGO to get the most optimized increase of the whole network reliability.

Firstly, all links got the same increase of government support when the links have the same original reliability under the same funds. Secondly, all links got the gradual increase of government support or have the different original reliability under the same funds. Thirdly, the discrepancy of the original reliability among all links was changed sharply in order to look for the rule of the increase of network reliability. During the process of simulation, some except results can be got and the viewpoint that it is difficult to improve more reliable links than less reliable links can be certificated.

4. CONCLUSION

These conclusions can be got from the variety of three network reliability based on government support:

(1) In series network, the link which got more government support should be strengthened when the two links have the same original reliability, and the link which has a lower original reliability should be strengthened when the two links got the same government support. If the discrepancy of the original reliability between the two links is not obvious, the link with a lower original reliability should be strengthened, and the link with a higher original reliability should be strengthened only after getting more especial great government support. On the contrary, if the discrepancy of the original reliability between the two links is very obvious, the link that has a lower original reliability should be strengthened no matter what the other link was given more especial great government support.

(2) In parallel network, one link which got the same great government support should be randomly strengthened although the two links have the same original reliability. The link which got more government support should be strengthened when the two links have the same original reliability. The link with a lower original reliability should be strengthened when the two links got the same little government support. And the link which has a higher original reliability should be strengthened when the two links got the same especial great government support. If the discrepancy of the original reliability between the two parallel links is obvious, the link that has a higher original reliability should be strengthened when this link can get enough support, and the link that has a higher original reliability shouldn't be strengthened under the especial little government support.

(3) In simple bridge network, when the links have the same original reliability, all main minimal paths should be strengthened when the links have got the same little government support, one main minimal path only should be strengthened when got the same great government support, and the main minimal path which got more support should be strengthened. The main minimal path with a lower original reliability should be strengthened when the paths got the same little government support, and the main minimal path with a higher original reliability should be strengthened when the path got the especial great government support.

(4) The effect of government support is limited and is nOt obvious when government support exceeds a critical point.