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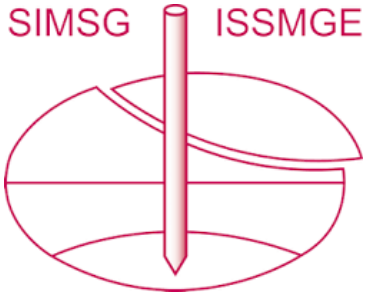

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Road slope stabilisation in Nepal: stakeholder perspectives

Ellen Robson, Stefano Utili, David Milledge & Nitish Upadhyay

School of Engineering, Newcastle University, U.K.

e.b.robson2@newcastle.ac.uk

Abstract

The Government of Nepal aims to expand the road network density threefold from 2015 to 2030. As 43% of construction triggered landslide events in Nepal occur along roads (Froude & Petley 2018), sustainable and effective slope stabilisation measures are critical to prevent social and economic losses from occurring in the future. There is a substantial body of literature offering guidelines on slope stabilisation design and construction. However, evidence suggests that this advice is sometimes ignored either on the strategic or local road networks of Nepal. This paper analyses the findings of a series of interviews, discussions and surveys carried out in consultation with the key stakeholders in road construction that includes slope stabilisation in Nepal (consultants, contractors, donor agencies, governing officials and construction workers). This research aims to make sense of issues surrounding the coordination and protocol of implementing road slope stabilisation, and to discover why informed advice isn't being taken up. The critical themes that arise are as follows: government engineers have insufficient experience with slope stabilisation; the road construction tends to be haphazard; there is poor communication between stakeholders; there is a lack of road project evaluation; and, slope stabilisation is not being prioritised in road construction. It is argued here that the communication and trust between stakeholders involved in slope stabilisation needs to drastically improve and that the perception of the importance of slope stabilisation in government agencies needs to be heightened. Based on these findings, it is advocated that future research and practitioner studies should focus on firstly, communicating the losses involved when slope stabilisation is not considered in road construction; and, secondly, on management strategies to improve slope stabilisation protocol within road projects.

1 INTRODUCTION

Nepal's road network hosts evidence of a patchwork of road design and construction due to the rapid expansion of the network over the last three decades, with many stakeholders at play (Rankin et al. 2017). Several academic and practitioner studies have focused on slope failures associated with roads in Nepal (Scott Wilson 2001, Hearn 2002, Dahal et al. 2010, Hearn 2011, Hearn and Shakya 2017, McAdoo et al. 2018, Sudmeier-Rieux et al. 2019) due to the devastating direct and indirect economic and social loss incurred with this scenario (Froude and Petley 2018, McAdoo et al. 2018). Nepal experiences tectonic-induced uplifting and water-based down-wasting due to its geographic positioning within the Himalayan mountain range. These contrasting forces are conducive to slope instability (Hearn and Shakya 2017). The likelihood of slopes failing along roads is exacerbated due to badly planned road alignments, the haphazard construction of roads and a lack of slope stabilisation measures. This can be observed in the strategic and local road networks of Nepal. There is an inextricable link between road construction and slope failure (Lennartz 2013). Foude and Petley (2018) found that in Nepal, 43% of landslides that are triggered by construction occurred on roads. This can be compared with a figure of only 7% in China (Froude & Petley 2018).

When slope stabilisation is considered, the pliable design and construction specifications and standards can result in structures failing (Shakya & Nirula 2008, Rural Access Programme (RAP) Phase 3 2016, Hearn & Shakya 2017). The Government of Nepal: National Planning Commission (2017) "Sustainable Development Goals" report outlines that in 2015 the road density of Nepal was 0.55 km per km^2 and by 2030 aim to raise this figure to 1.3 km per km^2. This is motivated by the Rural Access Index of the UN's Sustainable Development Goal 9.1.1: "*Proportion of the rural population who live within 2 km of an all-season road"* (United Nations 2016). According to the 'Nepal Economic Outlook 2018/19' (Regmi et al. 2019), 71.6% of the 60,162 km local roads constructed in the 2018/19 FY are "earthen", *i.e.* not paved. As observed in the field, Nepal's "earthen roads" have little/no slope stabilisation and drainage works along them, yet 41,160 km out of the total were constructed in a hilly or mountainous area. Rural Access Programme (RAP) Phase 3 (2016) suggest that by 2011 55% of the Local Road Network in Nepal that had been constructed since 2000 was unusable due to a lack of maintenance (including slope stabilisation). This equated to a loss of investment that is estimated to be equivalent to US$ 1 billion. With the push to expand Nepal's road network by 2030, a lack of attention to slope stabilisation could lead to more roads being unusable in the future and further loss in investment.

Many of the aforementioned research studies conclude that sustainable design and construction protocol of slope stabilisation is needed on new road cuttings and for landslides remediation (Dahal et al. 2010, and Hearn & Shakya 2017, Sudmeier-Rieux et al. 2019). However, the qualitative data collected in this research suggests this advice is not readily followed.

This paper will discuss the outcomes of a series of interviews and discussions conducted with key stakeholders involved in road slope stabilisation in Nepal. This research aims to comprehend the main issues surrounding the coordination of and protocol for road slope stabilisation in Nepal from the perspective of those involved. This will aid future studies that aim to improve road slope stabilisation in Nepal in giving clarity to the current obstacles and how they can be overcome.

2 NEPALI ROAD NETWORK AND SLOPE STABILISATION

Nepal's physical geography can be split into three well-defined regions forming belts: the mountains, the hills and the Terai (planes). In 2015, Nepal adopted a new Constitution with a three-tier government structure of federal, provincial and local levels (Constituent Assembly Secretariat 2015). Nepal is now administratively split into seven provinces that can be further divided into 653 Local Governments of Gaunpalikas and Nagarpalikas. The country is situated in a region of active tectonism and has an annual monsoon season. These harsh environmental conditions are responsible for damaged roads, as well as other infrastructure, across Nepal (Hearn & Shakya 2017).

The Department of Roads (DoR) are the central governing body for roads and are responsible for the Strategic Road Network (SRN). The SRN comprises the national highways. The provincial and local governments gained the responsibility of the Local Road Network (LRN) as a result of federalisation (Rankin et al. 2017). The LRN comprises feeder road that connect the national highways, as well as district and urban roads. The Department of Local Infrastructure (DoLI)

provides technical support to the provincial governments to ensure they develop their infrastructure in accordance with the Government of Nepal's (GON) National Strategy for Rural Infrastructure Development (Government of Nepal 2018). DoLI was formerly the Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) in the previous government constitution.

Multiple international donor agencies have had a strong presence in Nepal to help improve the resilience of its infrastructure to natural hazards (earthquakes and heavy rain) (Rankin et al. 2017). This includes preventing landslides along roads. Over the last two decades, Nepal's road network has quadrupled in length (Government of Nepal 2016). This growth has been prioritised by the GON and supported by international donor agencies (Rankin et al. 2017). As such, Nepal's road network hosts evidence for a variety of different slope stabilisation design and construction protocol, with variable levels of success.

Slope stabilisation is a measure that increases a slope's ability to withstand movement. Typical slope stabilisation measures implemented along roads in Nepal are concrete retaining walls, gabion walls, bioengineering, mortared masonry walls and cutting to a prescribed angle. Following a landslide, sometimes the slopes are left to stabilise naturally (Hearn and Shakya 2017).

3 RESEARCH METHODS

Seven semi-structured interviews and ten discussions were conducted in November 2019 with key stakeholders that included consultancies, contractors, international donors, governing officials from the Department of Roads (DoR), other departments within the GON and provincial governments. The interviews mostly took place in Kathmandu at participants' offices. However, some took place in the Districts of Chitwan and Lalitpur in provincial governing offices and on-site road projects. The interviews were recorded on a Dictaphone and typically lasted around an hour. The discussions ranged from 30 minutes to an hour and were not recorded. Despite all interviews and discussions taking place in English, a junior engineer from Scott Wilson Nepal was present in all meetings for any language clarification required. Table 1 details type of qualitative data collection used with participants from various organisations.

Table 1. Interviews (int.), discussions (disc.) and surveys (surv.) for Qualitative Data Collection

Organisation	Int.	Disc.	Surv.
Consultant	3	2	0
Contractor	0	2	0
Donor agency	2	1	0
Department of Roads	1	1	0
Other government departments	2	0	0
Provincial government	0	2	0
Researchers	0	2	0
Construction workers	0	0	6

Structured questionnaires were used to survey six construction workers on-site different road slope stabilisation projects in Chitwan and Lalitpur. The surveys were in Nepali and a translator was present to clarify the questions. They generally took around 20 minutes to complete.

The interviews, discussions and surveys aimed to solicit the opinions of these stakeholders on the key issues surrounding the coordination of slope stabilisation and landslide prevention along roads. It is understood that there is potential bias in this data collection, with only two provinces represented by governing officials outside of Kathmandu, and these both bordering Kathmandu. In addition, no members of the public participated in the qualitative data collection.

The qualitative data was analysed using NVivo (NVivo 12 released in 2018) by creating codes for key recurring themes. These themes are discussed below, with quotes from the interviews used for illustration.

4 DATA COLLECTION OUTCOMES: ORGANISATION OF ROAD SLOPE STABILISATION

Fig. 1 displays an organisational chart for road projects that encapsulate slope stabilisation and landslide remediation in Nepal. This chart and the information discussed in the following section has been compiled through consultations with consultants, contractors and governing officials.

The chart outlines the main role of key stakeholders in the hierarchy of a road project.

Road works, including slope stabilisation or landslide remediation, along strategic roads are under the jurisdiction of the DoR, whilst works on local roads are the responsibility of the Provincial and local governments (supported by DoLI). International donor agencies sometimes fund SRN or LRN projects, depending on the economic and

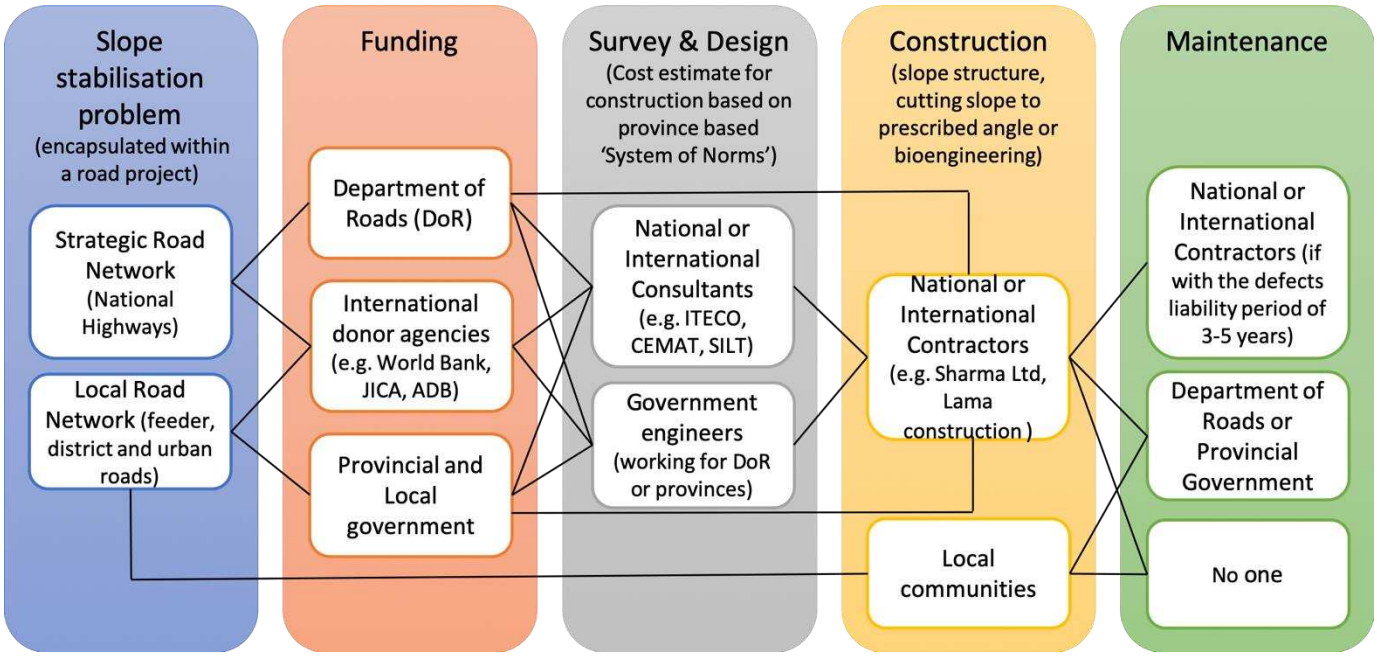

Figure 1: Organisational chart for a road slope stabilisation project outlining the roles of key stakeholders.

social significance of the road and the strategy of the donor agency. Donor agencies can either partially support government projects or fund a project entirely (generally having control over project aims, coordination and implementation). The survey and design of the slope stabilisation measure are either carried out by consultants (international or national based on the scale of the project) or engineers working for the DoR. Contractors (international or national) then bid to carry out the works and will hire construction workers. On-site supervision should be carried out by the design consultants and contractors. Occasionally, DoR and provincial government funded projects just hire contractors themselves.

Consultants bid for the work based on the technical expertise they can offer to complete the survey and design in a competitive timeframe. Contractors bid with their price for construction as the key competitive deliverable. The consultants designing the solution use a system of rate analysis to give standardised contract costing estimates for budgeting and tendering purpose ("System of Norms"). This design is often altered according to the available budget. Contractors based in Nepal can bid on projects up to a value of two billion Nepali Rupees (~ US$ 1.7 million). If the work in a project is estimated to be more than this, it is offered to international contractors. In some cases, international contractors that are specialised in carrying out a specific job (e.g. bioengineering) can be hired.

It is important to note that the organisational chart (Fig.1.) does not have a concurrent timeframe as projects can take a variable amount of time to complete. Individual roads/sites may also go through this process multiple times.

The responsibility for the maintenance of the measures depends on the defects liability period (DLP). If maintenance is required within the DLP, then it is the contractor's responsibility to carry this out. Only recently, has the DLP for typical road projects become 3-5 years (Discussions with governing officials, November 2019). If maintenance is required outside of the DLP, then this is the responsibility of the governing department for the specific road. Some rural roads are also cut by individuals or local communities. If the local government does not take over the responsibility for these informal roads, it is left with no one. It was stated in the Nepal Road Sector Assessment Study that 40% of the SRN that is unpaved does not receive any form of maintenance other than *ad hoc* repairs (World Bank, Government of Nepal 2013).

An example of how slope stabilisation can be coordinated within a road project is the Mugling-Narayanghat section of national highway. Over 90% of Nepal's daily consumer goods, commodities, industrial raw materials and fuel are transported along this critical corridor (Government of Nepal 2016). The road was constructed from 1978 to 1982 along valley side of Trishuli River (Hearn & Shakya 2017). A widening phase that commenced in 2015 instigated a host of

slope stability problems. The World Bank has funded the stabilisation of these problematic slopes. This road is now being used by the World Bank as a field site for training local engineers (Discussions, November 2019).

5 DATA COLLECTION OUTCOMES: SLOPE STABILISATION COORDINATION AND PROTOCOL ISSUES

The following key themes emerged through the analysis of the qualitative data collection (section number in parenthesis):

- Government engineers lack expertise (5.1)
- Haphazard construction of roads (5.2)
- Poor communication between stakeholders: a blame culture (5.3)
- Lack of project evaluation (5.4)
- Slope stabilisation is not a priority (5.5)

5.1 GOVERNMENT ENGINEERS LACK TECHNICAL EXPERTISE

Participants were asked their views on how provincial departments gaining responsibility for local infrastructure has affected road construction in Nepal, as discussed in Sudmeier-Rieux et al. (2019). Some participants suggested that it was too early to judge the impact of decentralisation, as the governance is still in a transitional period. However, three participants suggested that the provincial departments did not have the expertise to deal with landslides along roads. A design engineer working for a department of the government shared their worries, stating:

"*So just by assigning or writing in the laws, or constitution, the expertise wont trickle down to the local level. That is happening now, that means, they are assigned too many to play many role in the field disaster mitigation. But they don't know. The local bodies don't know how to do, they lack the expertise.*"

Although there seems to be no formal training for provincial government engineers, DoLI exists to technically support the provincial governments.

An issue brought up by all participants was the lack of geological and geotechnical knowledge of engineers hired by the DoR. This was commonly blamed on the fact that DoR engineers are readily transferred between provinces and projects, leading to a lack of technical experience in slope stabilisation. One interviewee stated:

"*So, a person, working in the field or river protection work, he would be transferred here, and he doesn't have any understanding of the landslide or slope protection works. He does it in his own way, and he gets transferred again after two/three years. So, in such way, I don't think landslides can be mitigated.*"

Participants stated that civil engineers working for the DoR can be transferred from projects that have no focus on slope stabilisation (*e.g.* bridge building) to projects where slope stabilisation is the main focus (*e.g.* landslide remediation). This can happen every couple of years. It was also suggested that the engineers may not see out the course of an entire project which can lead to a knowledge gap in the design, construction and maintenance of a slope structure. In addition, many of the consultants stated that geological training for engineers is not common practice, despite the fragile geology they have to contend with.

5.2 HAPHAZARD CONSTRUCTION OF ROADS

As previously mentioned, Government of Nepal: National Planning Commission (2017) 'Sustainable Development Goals' report outlines the aim of expanding Nepal's road network density from 0.55 km per km^2 in 2015 to 1.3 km per km^2 by 2030. This aim has been set out by the government and most participants of the qualitative data collection suggest that this wins public support. One participant suggested that the government has projected a mindset that 'roads equal development' to the public. It was suggested that this mindset is mirrored by certain communities and individuals, motivating them to construct their own roads, with no provision for drainage and slope stabilisation. These informal roads can be observed in the rural regions of Nepal and can trigger landslides where they undercut slopes (McAdoo et al 2018). Most participants suggested that roads are being cut haphazardly with the quality of construction not being a priority.

On government funded road projects, it is common practice for slopes to be cut to a prescribed angle for stabilisation with no additional structures. In the widely used 'Nepal Road Standard 2070' manual (Government of Nepal 2013), this prescribed angle is based on the height of the slope and a fairly arbitrary scale for material type (soft to hard rock). Speaking about government funded road construction, an engineer working for an international donor stated:

"*But haphazard type of construction method. All the time bulldozer. They don't care, you see, the*

minimum slope to be maintained. It's not designed. Non-designed, bulldozed roads.".

In 2017, the heavy equipment manufacturer JCB sold more backhoe loaders and excavators to Nepal than any other country in South Asia (Republica 2017). This widely available equipment is used for cutting informal and formal roads all over Nepal. When asked how long it would take to cut a kilometre section of road, all construction workers said that this would take 1-3 days with an excavator, but 5+ days with a labour-based approach (*i.e.* without heavy equipment). Haphazardly cutting into a valley-side with a bulldozer lacks precision and safety (Rural Access Programme (RAP) Phase 3 2016). If this cutting is undertaken without prior survey or subsequently stabilisation measures, landslide can be triggered (Petley, Hearn, Hart, Rosser, Dunning, & Oven 2007).

5.3 POOR COMMUNICATION BETWEEN STAKEHOLDERS: A BLAME CULTURE

After carrying out multiple interviews and discussion it became apparent that there can be lack of communication between the stakeholders at the different levels of hierarchy for a road project. This results in a culture of blame between the stakeholders and a lack of coherent road building strategies and techniques employed. The consultants often blame a poor design on the lack of budget from the client (DoR or Provincial authorities). As the government engineer stated:

"*There is not budget as per requirement but work as per budget*".

Some consultants say that the contractors do not follow the design specifications and try to cut costs where they can. One consultant stated:

"*And you know, we cannot control the contractor...they do it haphazardly you know. They do the cutting haphazardly, they do not follow the proper procedure, they do not carry out any of this water management. And normally what they do due to low-cost, they just cut and throw on the valley side. And this invites havoc.*"

As mentioned, the DLP for contractors has only recently been extended from one year (Discussions, November 2019). In the past, this could lead to a lack of care by the contractors in the quality of the construction. The contractors can be financially penalised to up to 10% of the project cost if the work is delayed. One contractor said that getting an extension from the government is difficult and can sometimes take more time than its worth. This can mean that the works are sometimes rushed. One contractor stated the contractors in Kathmandu act as a cartel. They will come together to bid for the works to ensure they win the works over international contractors.

The construction workers that participated in the surveys were all employed by contractors and were working on strategic roads. On average a construction worker was paid 1000 NPR per day (~ US$ 8.7), working for 8 hours a day. All participants complained about bad working conditions on-site, stating that the biggest challenges are lifting heavy materials above their heads with a lack of safety equipment. Bad working conditions could result in poor quality construction. This is the responsibility of the contractor.

An employee of an international donor agency working in Kathmandu stated that there is a lack of communication between donor agencies supporting road projects in Nepal. It was suggested that there is no common agenda between the donors themselves and between donors and the DoR. This can be observed with a patchwork of project types and construction protocol across the entire road network of Nepal. This also means that funds are not spread evenly over Nepal's road network.

5.4 LACK OF PROJECT EVALUATION

Annually following the monsoon season that runs from June-September, works are commonly required to repair and reconstruct slope stabilisation measures and to remediate landslides along roads. A few years after their initial construction, roads in Nepal are commonly upgraded to increase capacity. Project reports from these road works can be difficult to come across. The information held in such reports is invaluable to the speed and success of future projects along the same roads.

When asked about the road project evaluation protocol, mixed answers were received. An engineer working for the government stated:

"*There is no such practice I think*"

Some of the consultancy's answers were in agreement with this statement, whilst one consultant said:

"*...after the project completion, we are not responsible for that. So that we hand it over to the Department, he should take this responsibility to continue this job. That is lacking in Nepal.*".

However, an engineer from a different consultancy suggested that consultants carry out evaluation during the project and upon completion.

Such evaluation could also hugely benefit future projects in similar terrain.

5.5 SLOPE STABILISATION IS NOT A PRIORITY

A consistent and worrying outcome of most interviews is the perceived lack of awareness in the importance in slope stabilisation from the governing officials. This is translated into the budget for road projects, with slope stabilisation sometimes making up only 5-7% of a road construction projects (Discussions, November 2019). Most interviewees stated that they know that more focus should be put on road slope stabilisation, but that it is not prioritised. An engineer working for an international donor suggested that:

Knowledge is not acknowledged by policy makers. We lack proper planning, maintenance lacks...".

A lack of value placed on road slope stabilisation can lead to huge economic and social losses when road slopes collapse. Petley et al (2007) partially attribute the steep rise in landslide fatalities in Nepal from 1975-2005 to poorly constructed roads.

Consultant's report that there is lack of ability to negotiate government budgets leading to less investment in the slope stabilisation part of a project. Often the initial slope stabilisation budget in a project is underestimated compared with what is actually spent in the long-term. As one consultant stated:

"*There would need to be a 20% cost at start of project to stabilise slope properly*"

With the value of slope stabilisation underestimated at the start of a project, thorough geotechnical and geological investigation is cut back on. Most respondents suggested that less than 1% of a road construction budget is spent on geotechnical and geological investigation. All consultants suggest that more money needs to be spent on investigation but that it is difficult to communicate this to officials. They blame this on perceived lack of value placed on investigation by governing officials, as the benefits of investigation are hidden. A lack of investigation can cause problems further into the project, with the design not being based on accurate geotechnical parameters.

6 CONCLUSIONS

This research aimed to shed light on the key issues surrounding the coordination and protocols for road slope stabilisation in Nepal from those involved, to better direct future research and guidelines in slope stabilisation in Nepal.

The priority of the Government of Nepal is to open roads and connect communities. There is no clear strategy for this road building. Sustainable slope stabilisation is not at the forefront of importance for many roads currently being constructed. None of the stakeholders are taking responsibility for slope stabilisation and a blame-culture currently exists between all stakeholders involved.

Future academic and practitioner studies on slope stabilisation need to understand and target the issues surrounding slope stabilisation as established in this paper. The sustainable implementation of slope stabilisation along roads can only be achieved with well-established coordination and protocol in Nepal. Communication and trust between stakeholders must improve, with the perception of the importance of slope stabilisation heightened. This is something that should be initiated by the government. Based on the findings of this research, we advocate for future research and practitioner studies to emphasise the importance of slope stabilisation by demonstrating the benefit of investment. Creating tools and software that can be used by practitioners for designing and estimating the cost of slope stabilisation that can be trusted by governing officials would aid communication. Legislating a minimum geotechnical investigation quota for slope stabilisation design would hugely improve the quality of works carried out and if implemented with training, this could improve the expertise of the engineers.

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