Multi-stage Road Safety Auditing to Maximise Development Impact

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Key Findings

- Road safety auditors should be involved early for best outcomes
- Commitment to road safety is required from all stakeholders
- High risk projects should include multi-stage audits
- Infrastructure is only a part of a safe road system

Abstract

Development institutions including the World Bank recognise that road safety is a critical issue for investments in low and middle-income countries (LMICs). Inadequate consideration of safety disproportionately affects the poor; the very group which Governments and development institutions strive to lift from poverty. Road safety audits (RSA) are an effective way of addressing safety, however, their systematic use is often lacking. RSAs are also often completed too late for their full potential to be fully realised. To address this, the World Bank with support from the Global Road Safety Facility (GRSF) trialled the systematic application of multi-stage RSAs. The goal was to integrate road safety into the project design, with RSAs undertaken at feasibility, detailed design and post-construction stages. This approach is innovative for a project in a LMIC, and aimed to overcome the design inertia often observed when RSAs are undertaken later in projects. The results of a case study from the Kiribati Road Rehabilitation Project (KRRP) are presented. The approach resulted in a road design with extensive and well detailed safety features including a narrow carriageway, footpaths, speed humps, street lighting and gateway treatments. For the KRRP, pedestrians were the key vulnerable road user and the risk to them was expected to increase as a result of speed increases due to improved road condition. However, it was found that by applying a multi-stage RSA approach, improvements in road condition were made in parallel with features which decreased the safety risk to Kiribati's most vulnerable road users.

Keywords

Auditing, poverty, development, design, vulnerable, investment

Introduction

International development institutions have set an ambitious target as part of the United Nations (UN) Decade of Action for Road Safety, to stabilise then reduce global traffic fatalities by 2020 (UN, 2010). This is a particularly challenging target for low and middle-income countries (LMICs), where rapid urbanisation and motorisation of their populations is creating large populations of vehicle users which increase the risk of accident trauma. These risks also disproportionately affect the vulnerable users who are typically poorer, such as pedestrians, cyclists and motorcyclists. Development organisations are conscious of these risks, and often use road safety tools to ensure investments are as safe as possible, minimising the harm caused by their investments.

One powerful but underutilised tool to address these issues are road safety audits (RSAs). They consist of a formal qualitative examination of the safety performance of an existing or future road, providing recommendations which help to ensure infrastructure is as safe as possible (AUSTROADS, 2009).

RSAs can be conducted at various stages in the project life including feasibility, preliminary design, detailed design and pre-opening or post-construction stages. It is recognized that the earlier a road is audited within the design and development process, the better as it allows for adjustments to be made in the design with minimal risk of redesign or physical rework. Despite this, it is typical in development projects for RSAs to be conducted only at the detailed design stage, if at all.

The challenge with auditing only at the detailed design stage is that road safety features which fundamentally affect the design solution can only be fully considered if there is a

standard audit approach. This is often missing, particularly for road projects in LMICs. As a result, the opportunity to introduce innovative road safety solutions is missed, with designs often developed to such an extent that modifications for road safety may significantly delay the project, and/or increase the costs. For design teams working on lump sum contracts there is also reticence to do anything that could be considered rework.

An approach which has not been widely used on development projects is to conduct auditing at multiple stages throughout the life of the project. Adopting a comprehensive approach with audits at feasibility, detailed design and post-construction stages leads to a road which is much safer, particularly for vulnerable users. Through documenting the benefits of this multi-stage RSA approach which is novel for a development project, a case is made for the wider use of this methodology on road rehabilitation projects which pose a high risk of user trauma, particularly those in LMICs.

Background

Country Context

With an estimated population of 110,000, Kiribati is a small, remote country on the equator comprised of 33 atolls and reef islands, of which 21 are permanently inhabited. The total land area is only 726 square kilometres spanning approximately 3.5 million square kilometres of ocean (Central Intelligence Agency, 2016). The location of Kiribati is shown in Figure 1.

Approximately 60,000 of Kiribati's population reside in the capital of South Tarawa which is a magnet for internal migration from outer islands, with population growth of 4.4 percent a year (Office of Te Beretitenti, 2012). South Tarawa provides employment opportunities, as well as access to education and social services not available elsewhere in Kiribati. The United Nations Development Program (UNDP) noted that South Tarawa has a high incidence of basic needs poverty which affects one quarter of the population (UNDP, 2010).

Existing Road

In South Tarawa, the community is linked by a single main two-lane sealed road and four causeways that run east to west (Figure 1). For the majority of its length, the road passes through ribbon development comprising residences, businesses, schools and hospitals, all located within the confines of the atoll, which is less than three meters above sea level and has an average width of only 450 meters (World Bank, 2011). Virtually the entire population lives close to, and is affected by, the road's condition.

In 2010 the road system consisted of 36 km of bituminous sealed main roads (including causeways); 20 km of secondary roads (half of which are sealed and half unsealed); and 40 km of unsealed feeder roads. Road use on South Tarawa was growing rapidly: in central Bairiki, traffic volume on the main road reached 6,000 vehicles per day, growing at an average rate of four percent per year (PRIF, 2009). The estimated pedestrian traffic was 60,000 per day, so this vulnerable group was by far the largest road user.

While approximately 7 km of main road in Betio in the west of South Tarawa was rehabilitated in 2008 with finance from Japan, some 29 km of paved roads had received no major maintenance for over twenty years. The high traffic levels on the road combined with heavy rainfall during wet seasons caused extensive damage, with long sections of the road losing surfacing completely and reverting to an unpaved surface.

The state and condition of the roads in Kiribati had significant economic and social repercussions; particularly with regard to the health and safety of the population. The traffic speed was reduced in places to 20 km/h or less as a

Figure 1. Kiribati location and KRRP road layout (World Bank, 2011)

Figure 2. Poor condition of South Tarawa Road prior to the KRRP

result of the pavement condition. While lower speeds were advantageous from a road safety perspective, the driving conditions were hazardous particularly after rain (Figure 2). Further, during the dry season the dust from unpaved sections of the road contributed to widespread upper respiratory problems amongst local residents.

Project Objective

Recognising that the poor condition of the South Tarawa road was a key contributor to poverty in Kiribati, the World Bank together with the Asian Development Bank and the Australian Agency for International Development (now the Department of Foreign Affairs and Trade), hereafter referred to as 'donors', prepared the Kiribati Road Rehabilitation Project (KRRP). With the development objective of improving the condition of South Tarawa's main road network and helping to strengthen road financing and maintenance capacity (World Bank, 2011), a comprehensive investment and reform project was prepared. Funding for the project was approximately US$76 million including both the physical works and associated activities for road maintenance and safety (Asian Development Bank, 2016). Physical works started in July 2013, and were completed in December 2016.

Case Study Findings

Phase 1: Feasibility Stage RSA

During the early stages of project preparations, prior to design commencing, donors sought the expertise of a specialist road safety auditor. This was made possible with funding from the Global Road Safety Facility (GRSF), a global partnership program administered by the World Bank with a mission to help address the growing crisis of road traffic deaths and injuries in LMICs. The auditor selected conducted an existing condition RSA of the South Tarawa road corridor, for which the feasibility of rehabilitation was being considered. Typically, a feasibility stage RSA involves a review of broad design decisions such as route selection, an approach consistent with guidelines that suggest auditing the design brief for safety (AUSTROADS, 2009). However, the approach used for KRRP instead focused on existing issues which fed into the design brief. This was similar to the approach documented by Harris (2015) for a 1,500 km of highway in Tanzania, albeit with more detail due to the short length being considered under KRRP. The RSA conducted included several day-time and night-time site inspections with findings compiled in a report. This included a table of issues and recommendations for action by the designer (Road Safety International, 2010). An example of a safety issue raised regarding the hazard clear zone, and the subsequent recommendation is provided in Figure 3. This report was then provided to the engineering designers to ensure that the road safety issues were fully addressed from the commencement of the design stage.

Summary of feasibility stage RSA findings

This feasibility stage RSA found the following major issues with the existing road which required action in the design:

- Provision of footpaths in densely populated villages to reduce risk to pedestrians;
- Provision of bus-stops for better traffic management and to promote safer bus driving;
- Provision of pedestrian crossings at schools and other busy areas;
- Provision of proper signage and pavement markings;
- Improved intersection designs;

SAFETY CONCERN	RISK	RECOMMENDATION
There are numerous trees and houses, shops and other fixed objects within the clear zone along this road. There are too many to individually highlight, and it is expected that removal of the trees will not be a favoured option. The installation of crash barriers is not recommended – such barriers will nto fit in some parts because of inadequate widths for offsets and deflection. They will also cause 'innocent hits' when buses/cars pull too close.	High	• Design the road with suitable line marking and associated delineation to minimise the risk of a vehicle leaving the road. • Take into account especially the locations at each end of the causeways (where speeds will be highest) and ensure that delineation of the curves is excellent. • At selected locations install 2-3 chevron alignment markers (CAMs) to delineate a sharp curve. • Consider developing a program of tree removal to remove only those trees that are closest to the road in high risk locations (blackspots) at the end of the causeways.
		
The bridge on the Betio causeway is narrower than the road cross section. The footpath and the bridge railing are road side hazards. The design proposes a cantilevered footpath to serve pedestrians and to maintain the road width.		The Betio port road runs beside the sea – a safety barrier is now proposed to prevent a vehicle from dropping 4m into the sea here.

Figure 3. Example of feasibility RSA findings showing safety concerns and recommendations (Road Safety International, 2010)

- Provision of street lighting to improve safety at night in busy pedestrian areas;
- Speed control measures such as speed humps to mitigate the likely increased risk of speeding as a result of improved road conditions;
- Speed limits of 30 km/h through villages and 60 km/h through un-developed areas.

In addition to this, the donors supported the auditor's recommendation to reduce the combined traffic lane width from seven to six metres so as not only to create sufficient space for footpaths and shoulders, but also to increase vehicle 'friction' and reduce speeds.

The designers considered these recommendations during the detailed design, and conscious of the importance of road safety to both their client the Government of Kiribati, and the donors, they made commendable efforts to address as many of the recommendations as possible.

Phase 2: Detailed Design Stage RSA

In Phase 2, a RSA was conducted on the draft detailed design of the KRRP civil works. The auditor was the same individual who undertook the feasibility RSA, with an updated issue table prepared to assist the designers with refining the design (Road Safety International, 2011) – Figure 4 for an example on signage. Using the same auditor for feasibility and detailed design stage RSAs resulted in a consistency of input and made use of the relationship that had been established with stakeholders.

In the case of KRRP, this second audit continued a dialogue between designer and auditor to facilitate the process of agreeing details, with comments and responses tracked and

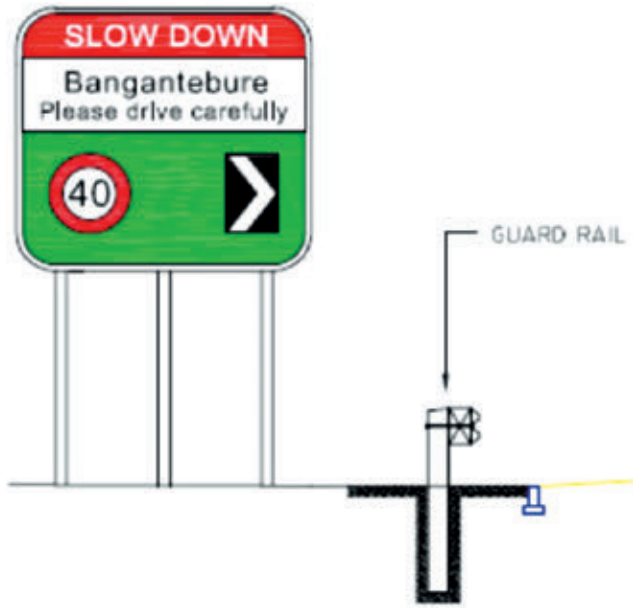
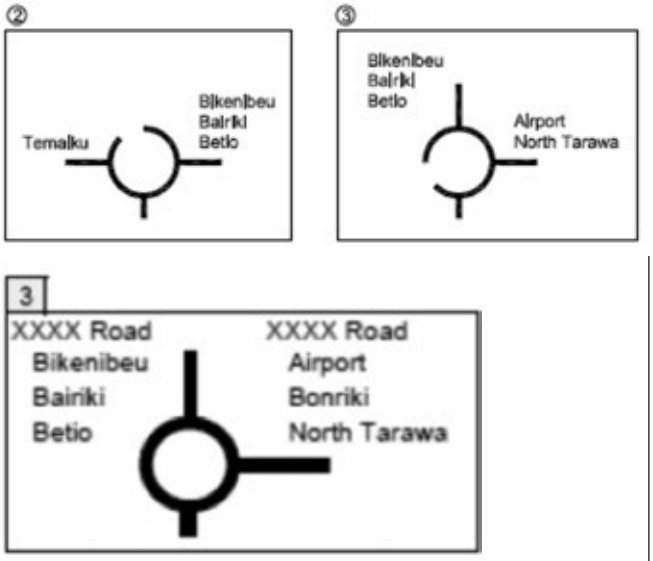
SAFETY CONCERN	RECOMMEDNATION
	
The proposed gateway sign is a good concept but the design is not as useful for safety as it could be. The hazard marker is incorrect and may confuse drivers. The term SLOW DOWN implies people are speeding and yet the speed limit in advance of this sign will be the same as after the sign (40km/h). Drivers should be told why they need to be careful – usually because they are entering an area with more pedestrians than elsewhere.	These signs shown for the roundabout proposed at the T junction of the Airport Road/main Road are incorrect. The "gap" in the circulating carriageway should always be just to the right of the entering road (ie just to the right of the road on the bottom of the sign). Sign No 3 is from Figure 17 in the draft design report. It needs to be reviewed and corrected together with the other diagrammatic directions signs shown there.

Figure 4. Example of detailed design RSA findings (Road Safety International, 2011)

reviewed by Government and donors. This feedback loop reduced the likelihood that recommendations would be ignored, addressing a common weakness of the audit process and developing greater ownership of road safety by project stakeholders.

Often designers and even some governments are reluctant to add safety features when only detailed design RSAs are conducted, with a desire to avoid rework fuelling this. However, because the design for KRRP included extensive safety features from the concept stage, the risk of rework to add safety features was reduced.

After modifying the design based on the RSA, highlights of the road safety detailing included paved footpath for the length of the main road (on both sides) - Figure 5. In addition, the designer went beyond the recommendations of the auditor to specify roundabouts at two key intersections (Figure 6). This indicates a strong commitment to safety which was fostered by providing the designer with a feasibility stage RSA. These and other features contributed to an overall safer design for the road rehabilitation, particularly for pedestrians who were the most numerous but also most vulnerable road users.

Summary of detailed design stage RSA findings

The detailed design RSA focused on refining the details for features recommended in the feasibility RSA. These included:

- Details for signage and line markings including chevrons for delineation, direction, warning and speed restriction signage;
- Provision of crash barriers including end terminal details;
- Details of street lighting including frangible poles;
- Intersection details including splitter islands at roundabouts, centrally placed lighting and channelisation of intersections.

It also separately raised new recommendations for inclusion in the final design including:

- Road cross section including raised kerbs and sealed shoulders;
- Pavement for bus stopping areas;
- Sealing of side roads back from junctions;

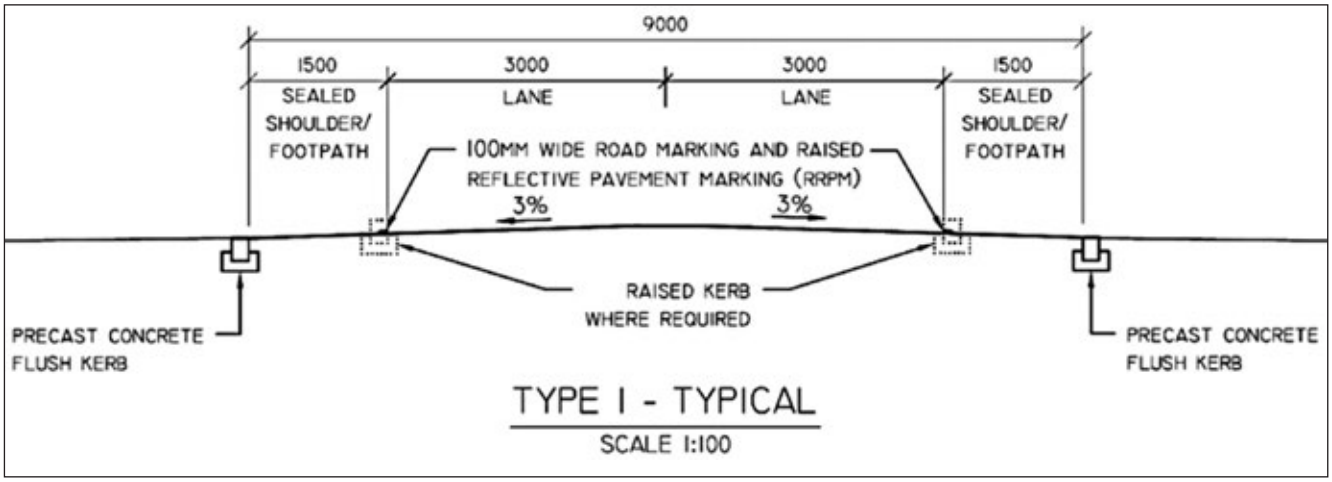


Figure 5. Typical road cross section for KRRP - Betio to Bikenibeu (Roughton International, 2011a)

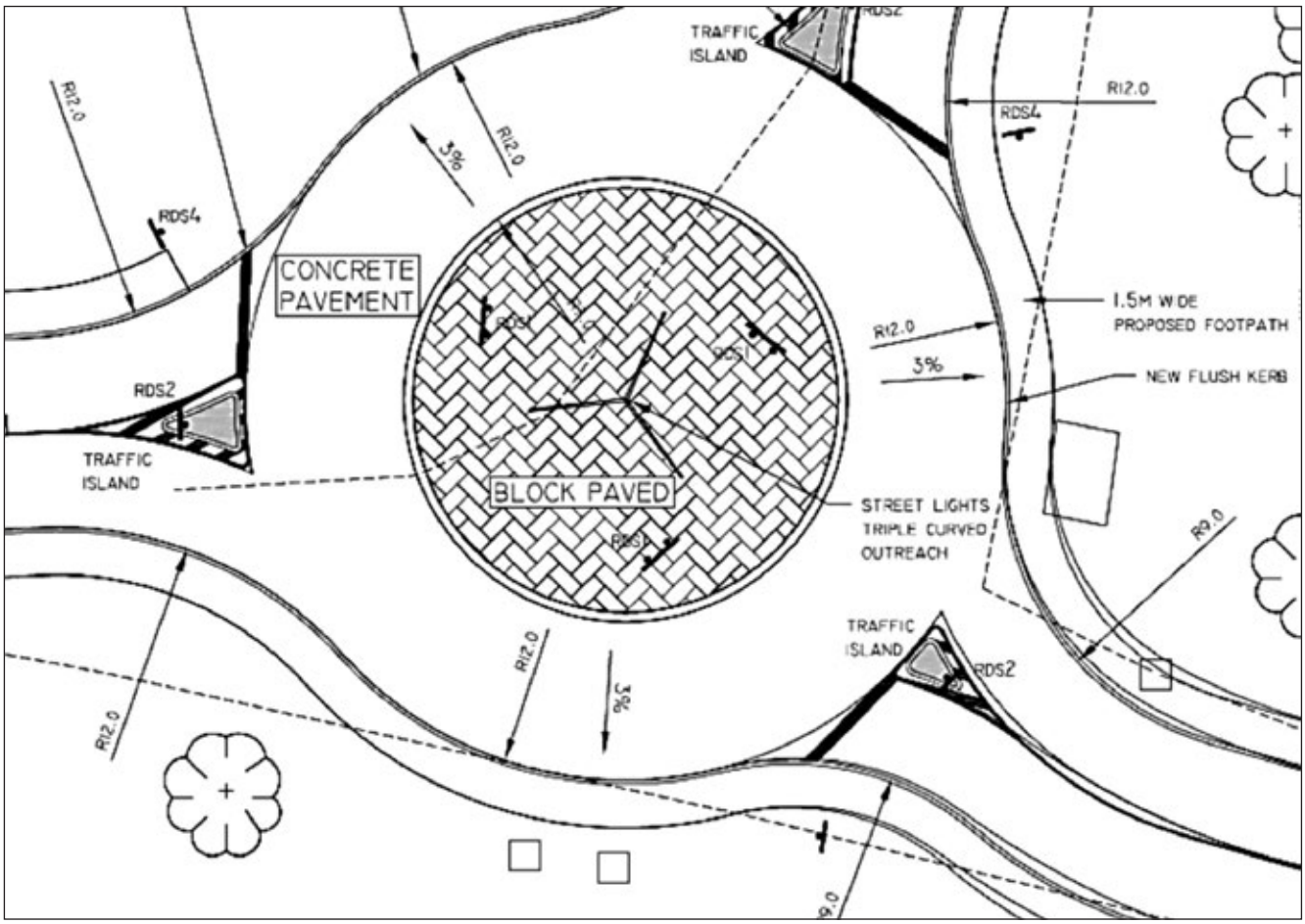


Figure 6. Temaiku roundabout (Roughton International, 2011b)

- Using crash barrier for shielding culverts and bridge abutments only;
- Consistent specification of speed humps (flat top type);
- Gateway treatment details at entrances to villages;
- Location of stopping areas.

Recommendations were provided to the designer with the requirement that they address them wherever possible. Given the design was based on the feasibility RSA, it already included many safety features such as speed humps, a narrow carriageway and gateway treatments.

Phase 3: Post-Construction Stage RSA

With the design finalised, it was tendered and awarded to an Australasian civil construction contractor McConnell Dowell who mobilised to Tarawa in July 2013. During construction, the supervising engineer provided clarifications to the contractor in the form of contract instructions, including many to ensure road safety features were correctly constructed. Close to completion of the works, a post-construction RSA was undertaken. This time, the auditor was a staff member of the World Bank who had experience with KRRP having visited regularly since the commencement of construction. The auditor was independent as required, but due to the constraints of timing, their RSAs were conducted over two visits spanning six months, prior to the completion, and again once outstanding works including line marking and signage installation were complete.

Summary of post-construction stage RSA findings

The post-construction RSA had a range of findings relating to issues with the design and construction as well as road user behaviour which could only be identified once the latter had been completed. It found that all the key issues identified in the Phase 1 feasibility RSA had been adequately addressed. While a number of hazards were identified, the majority were considered low risk. Hazards were classified as relating to signage, roadside hazards, intersections, lighting and other. The most common issues related to signage, which the feasibility RSA noted was almost completely absent from the road prior to rehabilitation. A common issue was the obstruction of newly installed signage by vegetation (Figure 7) which could be resolved by ongoing trimming of vegetation as part of routine maintenance (Whalley, 2017). Vandalism of signage was also evident, and while the contractor was subsequently instructed to replace affected signage, the limited ability of the Government to continually replace these remains a risk. High risk issues related to roadside hazards (including uncompleted elevated manhole risers) were raised. Also, the lack of a physical barrier for the traffic lane at speed humps meant some vehicles could drive around them in several locations. Swerving from the lane to pass clear of the speed hump was a risky manoeuvre which could be prevented by the installation of raised kerbs, which the audit recommended.

In terms of user behaviour, the audit observed that the key vulnerable pedestrians were in general using the footpath and shoulders, which was a safe behaviour. One dangerous behaviour observed was the use of raised kerbs as balance beams by children, where a fall could result in them entering the traffic lane. In terms of driver behaviour, while some were observed to be travelling considerably faster due to the improved road condition, others were travelling significantly below the speed limit. This speed discrepancy had the potential to be a source of user conflict, with faster traveling vehicles choosing to take risks to pass slower moving traffic, increasing the risk of head on and pedestrian crashes. These and other behavioural issues were raised with the Government, who undertook to address them through

Figure 7. Example of obscured signage (left) and completed road showing safety features including signage, line marking, lighting, speed humps, footpaths and drainage (Whalley, 2017)

an integrated information, education and enforcement campaign which was planned as part of their Road Safety Strategy Action Plan.

Recommendations were made for addressing all physical hazards for works that had been constructed, however at the request of donor and Government stakeholders the RSA also undertook a comparison with the existing conditions described in the feasibility audit, finding a significant improvement. This is beyond the typical scope of a post-construction RSA, but satisfied the request of stakeholders for a comparison of prior and post construction conditions.

In general, the auditor observed the general standard of both design and construction of road safety features to be good (Figure 7). The RSAs at feasibility and detailed design stages had clearly resulted in a very safe design, leaving mostly minor construction issues which were relatively simple to address in line with the recommendations of the post-construction RSA. The road safety features resulted in a much safer design, and if recommendations from the post-construction RSA were actioned, they would lift safety to an even higher level.

Road Safety Strategy and Action Plan

Recognising that infrastructure makes up only a part of a safe road system, the KRRP also assisted the Government of Kiribati with the development and implementation of a multi-sectoral road safety strategy and action plan, as well as updating legislation related to road safety.

The strategy and action plan were completed in January 2015 and adopted by the Government soon after (Selby, 2015). The Kiribati Road Safety Task Force committee were tasked with implementing the prioritised actions in the areas of:

- Leadership and coordination/capacity building;
- Speed management;
- Bus passenger safety;
- Road safety education and awareness;
- Driver testing/licencing;
- Vehicle testing/registration;
- Crash data system; and,
- Drink driving.

The Government has since made significant strides in implementing this plan, particularly in the areas of driver licencing, vehicle testing and enforcement of speeding and drunk driving. To improve enforcement in the key risk areas of speeding and drunk driving, the project has supported the Kiribati Police Service (KPS) with new equipment including radar speed detectors and breathalysers, calibration support and training by police counterparts from New Zealand and Australia. The revised legislation and regulations prepared will allow more effective enforcement in these areas, with the Government adopting both.

One of the priority actions under the plan was the implementation of a crash data system as the current traffic accident statistics for Kiribati are unreliable. An improved data collection and management system will allow for better monitoring of the impact of any road safety interventions, allowing for informed decision making to address risks. One option is for Kiribati to consider using the World Bank's open source software platform DRIVER (Data for Road Incident Visualisation, Evaluation, and Reporting) which was developed in the Philippines and adopted successfully elsewhere (World Bank, 2016).

Conclusions

From this case study there are several lessons which hold value for the preparation of new road rehabilitation projects. The RSAs at feasibility, detailed design and post-construction stages captured knowledge which can be used by the stakeholders involved in KRRP on other projects including those in Kiribati as well as other LMICs. Beyond this, the following lessons learnt are useful, particularly for situations where there is a large proportion of vulnerable users as in Kiribati:

Road safety auditors should be involved early for best outcomes

One of the great benefits of the project's approach was the fact that the feasibility stage RSA provided a clear set of recommendations as an input to the design, before the designer had even commenced. This early involvement of auditors had a high impact on the safety of the design, placing it at the forefront of the designer's consciousness. Safety appeared to be given similar importance as for technical aspects such as pavement and geometric design. While it required a larger upfront commitment from donors to organise and fund an audit, this cost is considered small compared with the overall investment and indeed the benefits which can be realised from reduced road trauma. Therefore, it is recommended that existing conditions RSAs be conducted at feasibility stage on all major road rehabilitation projects—particularly where vulnerable users may be a major consideration.

Commitment is required from all stakeholders

From the onset of the KRRP, all parties involved displayed an excellent commitment to making the road in Kiribati safer. While the early involvement of auditors required donor support and funding from the Global Road Safety Facility (GRSF), the Government of Kiribati were also committed after the road safety issues were highlighted. They too showed foresight and were willing to accept the likely higher cost of a road design with extensive safety features, knowing that this would have long term benefits from reduced road trauma. The designer also showed commitment to making the road as safe as possible within the constraints, and while having the feasibility RSA provided to them steered them in this direction, in some cases they went beyond the recommendations of the auditor.

The successful outcome seen on the KRRP only came about due to the commitment of donors, Government, contractor and the design and supervision consultant.

High risk projects should include multi-stage RSAs

The typical approach on development projects is to conduct audits only at detailed design stage, if at all. Unfortunately, this approach often comes up against design inertia, with designers and Government unwilling to revisit designs and specifications to include safety features for fear of re-work or increasing the cost beyond the available funding envelope. In high risk situations such as Kiribati where vulnerable pedestrians were by far the biggest road user, the best practice approach is to conduct RSAs at feasibility, detailed design and post-construction stages. This approach minimises the risk of rework and results in early estimates being developed with full cognisance of the cost implications of road safety. Following this, the detailed design RSA is required to ensure any features are correctly detailed. Finally, the post-construction RSA serves as an independent check of whether the previous RSA stages have performed well, and as for KRRP should typically only result in minor remedial work to enhance safety.

Infrastructure is only a part of a safe road system

The multi-stage RSA approach resulted in a road with comprehensive road safety features, particularly to protect vulnerable pedestrians. However, this is only part of creating a safer road system. In line with the UN's decade of action (UN, 2010), enforcement, education, post-crash care and management should all be addressed in order to minimise trauma resulting from any road improvements. The KRRP recognised this by preparing a road safety strategy and action plan for the road improvements. The Government, with support of the project has made progress towards addressing priority actions in this plan.

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