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Impact of Failure in the Planning Phase of Mega Infrastructure Projects:

A Case Study of Road Safety on Thika Superhighway

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Abstract

This paper reports the findings of a study that aimed to investigate the impact of failure in the planning phase of a mega construction project as exemplified by road safety challenges on the Thika Superhighway, Kenya. Accordingly, the study sought to identify whether the planned road safety measures were adequately implemented. The study therefore covered what the planning phase within the construction project lifecycle entails, the implementation of a road work zone including the various aspects of road safety that should be considered during the planning phase of a mega infrastructure project i.e., the best practice road safety measures. The study relied on purposive sampling of the key informants/opinion leaders i.e., the Employer (Kenya National Highways Authority), Traffic Police, Design Engineers (APEC Consulting Engineers Limited), the umbrella body of resident associations in Kenya (KARA) and the Contractors (China Wu Yi / Sino Hydro / Shengli) who had been directly involved in the project. The data was collected via interviews, questionnaires and focus group discussions (FGDs) for residents living along the highway. The findings indicated that failure in the planning phase had a direct impact on the implementation phase as exemplified by road safety challenges e.g., multiple fatalities and injuries during the highway construction. This was exacerbated by failure to involve all the stakeholders during the planning phase of the project and also failure by planners to fully consider road safety during the planning phase of the project as per the best practice. The study recommends the adoption of a context-sensitive approach to roadbuilding. The government should also emphasize the need for public participation and stakeholder engagement during the planning phase of mega road infrastructure projects in line with the Constitution of Kenya (2010). The road safety measures should also be planned and fully implemented as per the best practice.

Keywords: Accident, Mega infrastructure projects, Planning phase, Road safety, Work zone.

INTRODUCTION

Before plans for Nairobi-Thika Superhighway were designed, few would have imagined that this grand infrastructure project, one of the key pillars of Kenya's Vision 2030, would lead to a complete transformation of Nairobi. That is exactly what the Nairobi-Thika Superhighway, which links Nairobi and the industrial and agricultural towns of Ruiru and Thika has done (Kabukuru, 2011). According to CES & APEC (2008), the project road is part of International Trunk corridor (A2) which connects Kenya with Ethiopia, and is located in the central part of Kenya. The road lies within Nairobi and Kiambu counties. The project road starts from Globe Cinema Roundabout inside Nairobi City and ends at Thika, near the bridge across Thika River, after the flyover leading to Thika town. The total length of the project road from Globe Cinema to Thika is about 42.0km. The City Arterial Connectors comprises improvement of three Major Arterials connecting Nairobi-Thika Road at Pangani roundabout with Uhuru Highway (A104) at different locations along it. Total length of these connectors is 12.4km (CES & APEC, 2008).

Construction of this highway began in January 2009, undertaken by three Chinese construction giants. The highway was split into three sections for construction works of the multiple lane road. These sections were Uhuru Highway to Muthaiga Roundabout, Muthaiga Roundabout to Kenyatta University (KU) and KU to Thika (Lugaria, 2012). The key objective for the road expansion was to decongest the city and reduce the

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numerous traffic snarl-ups associated with this road, which is estimated to carry 70,000 vehicles daily, transiting between Nairobi and the countryside. Thika road construction project involved changing the road from a four to eight-lane superhighway (Kabukuru, 2011). The project, whose initial cost was estimated to be Ksh.27 billion, ended up costing Ksh.31 billion due to inflation and additional features that changed design work (Ngetich, 2012). The project included construction of interchanges, flyovers, box culverts and standard pipe culverts (Lugaria, 2012).

The gains of the expanded Thika road cannot be overemphasized, but some crucial social implications may have been overlooked. As many celebrate the ease of traffic flow occasioned by the Nairobi-Thika Superhighway, residents living along the highway were concerned about the social-economic impact the new road would have on their lives (Muiruri, 2011). The reality of such effects came to the fore in a brainstorming forum held between August and September, 2011 organized by the umbrella body of resident's associations, and attended by those living or doing business along the superhighway, and officials from the Employer. The meeting was the culmination of six other public forums held with residents along the highway (Muiruri, 2011).

The focus group discussions provided a platform for the public to give their views on project planning and implementation, socio-economic impact on their lives and livelihoods, their involvement or otherwise in the project, and issues of local planning and land use in relation to the project, as well as any other concerns (KARA, 2012). During the forum, residents isolated several negative effects that were likely to occur during and after the completion of the project, ranging from health, economic, social, environmental and road safety (Muiruri, 2011).

The above therefore suggests possible failure by the planners to consider stakeholder concerns. Accordingly, the following questions beg an answer: Were the issues raised by the various stakeholders factored in during the planning phase? If yes, were they adequately implemented? This paper therefore reports the findings of a study that aimed to investigate the impact of failure in the planning phase of a mega construction project as exemplified by road safety challenges on the Thika Superhighway. In particular, the study sought to evaluate whether the planned road safety measures were adequately implemented.

THEORY

Construction Project Lifecycle

Each construction project has a pre-determined duration, with a definite beginning and an identifiable end. Each project is therefore divided into several phases. A project starting point is the time when the idea or the need is conceived by the client, and its end marks the time when the mission is accomplished. The time between the start and completion of a project represents the project life cycle. Collectively, a project life cycle comprises of the project phases, from the beginning to the end of the project (Chitkara, 2009). The construction project lifecycle is comprised of various phases, such as: feasibility, planning and design, production, turnover and startup. The planning phase entails compiling detailed designs and drawings, planning project execution and tendering, and appointing contracts (Chitkara, 2009; PMI, 1996). A life cycle pattern of a typical construction project is illustrated in **Figure 1**.

Chitkara (2009), argues that the probability of successfully completing the project is lowest at the start of the project, and hence the risk and uncertainty are the highest. The probability of completion gradually increases, and the risks reduce as the project progresses. This generally implies that since risks and uncertainty are highest and costs are lowest at the start of the project, the project stakeholders are in a better position to influence project parameters such as cost, time, quality and safety at the onset of the project, unlike during the course of the project or even at the end. It is therefore crucial that important decisions are made during the planning phase of the construction project since this will have an impact on subsequent phases of the project, especially the construction phase. The road project's lifecycle is illustrated in **Figure 2**.

Implementation of a Road Work Zone

Road work zone phases

The implementation of a road work zone consists of

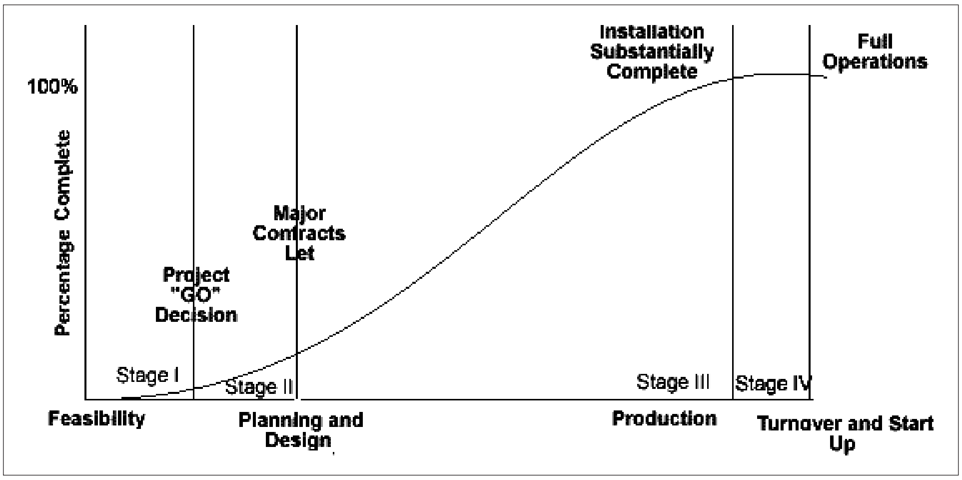


FIGURE 1
Typical construction project lifecycle pattern: Cumulative Effort v/s Time
Source: Chitkara 2009

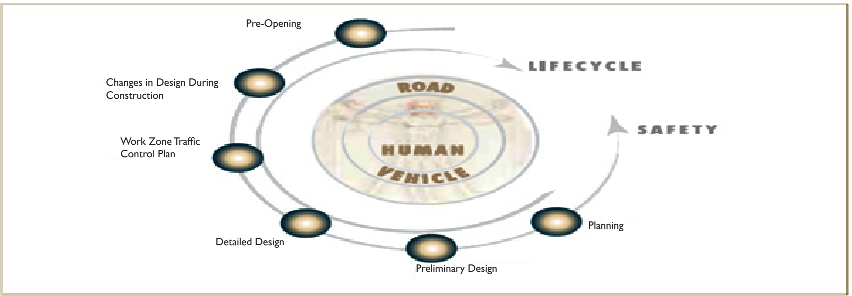


FIGURE 2
Road project's lifecycle
Source: FHWA 2006

the following five phases:

Phase 1 - Planning

According to Texas Department of Transportation (TxDOT) (1998), during the planning phase fundamental decisions about the road work zone are made, taking into account the wider context of managing the maintenance and/or construction of the affected road. When determining the timing, form and type of road works, a balance should be achieved between the following: safety of road users and workers, traffic flow and road user inconvenience, efficient work zone scheduling and economical traffic operation and environmental impact and other quality requirements. The impact of the road works as regards space, time and cost should be minimized as far as possible; at the same time, safety, environmental and other quality standards must be met (TxDOT, 1998).

Phase 2 - Design

The design phase is sub-divided into the following actions:

a) Data collection

Information is collected on the characteristics of the road segment directly affected and the adjacent road network, including: alignment; traffic volumes, patterns and composition; accident data; current (permanent) traffic control devices and other equipment; and alternative traffic routes. If available, national data bases could also be consulted. In addition, information should be collected on the type and methods of work to be carried out - as well as on road works on alternative routes and other adjacent sections. Finally, requirements on environmental protection should be known (TxDOT, 1998).

b) Road work zone design

The design involves the following steps:

Selection of the appropriate road work zone type - where possible, on the basis of typical layouts;

Preparation of a traffic control plan, specifying the type and location of safety measures;

Consideration of relevant aspects of work site operation and organization (e.g., entry/exit points, truck frequency);

Formulation of an emergency plan, specifying actions to be taken in case of incidents or accidents;

Specification of processes for monitoring the operation and safety performance of the work zone (TxDOT, 1998).

c) Check and approval

The design should be checked and, if necessary, revised prior to its approval (TxDOT, 1998).

Phase 3 – Installation

The installation phase is sub-divided into the following actions:

a) Instructions to workers

The workers should be informed about the organization and operation of the site, including all safety aspects, as well as about the emergency plan. Instructions should also cover the placement and removal of safety measures. Members of the site personnel should be assigned responsibilities and/or duties concerning safety.

b) Placement of safety measures

The safety measures should be installed according to the approved traffic control plan and positioned in the direction of traffic flow.

c) Pre-opening check

It is desirable to conduct both an internal check (by the site personnel) and, afterwards, an external one (TxDOT, 1998).

Phase 4 - Operation

The operation phase is subdivided into the following actions:

a) Observance of safety provisions

It should be ensured and checked that work zones operate according to the specified plans and procedures. However, it should be possible to alter the traffic control plan (or other safety provisions) at short notice, to enable whatever changes are made necessary for safety reasons, e.g., due to an unexpected emergency.

b) Check/audit

Road work zones should be checked closely and frequently/ periodically. The frequency of such checks should be determined by the importance of the road - for motorways, internal checks every 24 hours are recommended. Unannounced external audits should also be performed. Checking and auditing reinforces the importance of safety measures and identifies areas for improvement (TxDOT, 1998).

c) Evaluation

Aspects of the operation and safety performance of road work zones should be monitored and registered according to the processes specified in the design phase. The feedback from evaluation can contribute to the improvement of road work zone safety practices, as well as to the better training of road workers. It is desirable to collect such information using a standard format, so that it can be evaluated afterwards. Interim evaluation may also be feasible at longer-term work zones, leading - if necessary - to alterations of the traffic control plan (TxDOT, 1998).

Phase 5 - Removal

The removal phase is sub-divided into the following actions:

a) Withdrawal of temporary safety measures

This should be accompanied by provision of the correct permanent setting of traffic control and other safety devices. The safety measures should be removed against the direction of traffic flow.

b) Final check

This is a necessary last step. In countries where the road safety audit process is applied, the final check at work zones involving road construction/upgrading may be part of the so-called "pre-opening audit" - i.e., an examination of road safety aspects before the road is (re-)opened to traffic (TxDOT,1998).

Highway Work Zone

A highway work zone refers to a road section where a construction or maintenance project is carried out. Manual on Uniform Traffic Control Devices (MUTCD) divide a work zone into four areas, as shown in **Figure 3**: the advance warning area, the transition area, the activity area, and the termination area (FHWA, 2009). Road users traveling through a work zone are warned of the upcoming hazardous area in the advanced warning section, and then are directed out of their normal path in the transition area. The transition area frequently forms a bottleneck, which could dramatically reduce the traffic throughput. The termination area is the section following activity area where road users return to their normal path (Bai & Li, 2006).

In the advance warning section, road users are informed about the upcoming work zone or incident area. The motorists are advised they are approaching a work zone by warning signs, rumble strips, and radar transmitters. If an alternate detour route is available so motorists can choose to avoid the work zone entirely, advisory and directional instruction signs should be placed prior to its exit. Signage is designed and must be placed to give drivers clear information and instruction about what they must do to safely pass through the rest of the zone. Sign messages must be clear, short, and spaced correctly, so that the needed information is understood in time for the driver to safely perform the necessary maneuvers. Spacing will be based on the speed limit where drivers first encounter the signs. If warning lighting is in use, make sure that the light levels are adjusted in a timely manner. Bright daytime lighting can dazzle drivers during hours of darkness. Dimmer night light levels will not be readily visible in daylight hours. It has

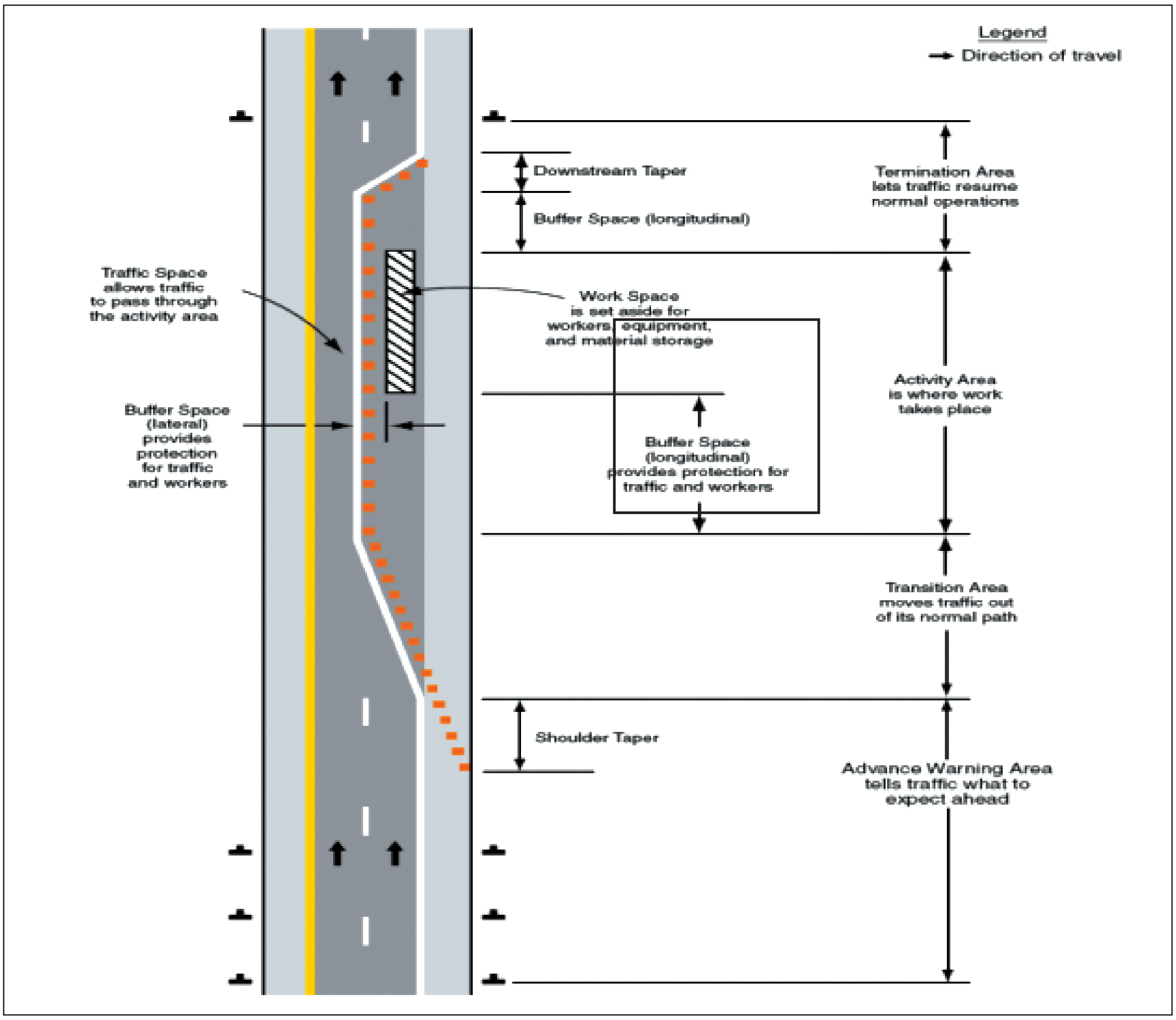


FIGURE 3
Component areas of a Highway Work Zone
Source: FHWA 2009

been found that the most effective warning device is an occupied, marked police vehicle, with its warning lights flashing. These should be used whenever possible for zones on highways with high speed limits, where the traffic control zones allow relatively high speeds. They should also be employed in urban areas, where there will be extra heavy traffic and, where work areas have to be very close to the traffic control lanes (FHWA, 2009).

Next, traffic enters the transition section where road users are redirected out of their normal path. Channeling devices, such as cones and barricades, will direct traffic into the safe lanes. The transition zone must be laid out so that motorists do not have to make abrupt changes of speed or direction. The third area is the activity section, where the work activity takes place. It is comprised of the work space, the traffic space, and the buffer space. The work space is that portion of the highway closed to road users and set aside for workers, equipment, and material. Work spaces are usually delineated for road users by channelizing devices or, to exclude vehicles and pedestrians, by temporary barriers. The traffic space is reserved for the motorists. Buffer spaces may be positioned, either longitudinally or laterally, with respect to the direction of road user flow. An adequate buffer zone between the traffic control zone and the work zone has to be constructed as part of the plan. A buffer zone needs to be of sufficient depth, with strong barriers placed between traffic and workers. Deflecting barriers should be placed where traffic will be running closely parallel to the work zone. The final section of the traffic control zone is the termination area, where channeling devices and signage return traffic to normal speed and lane configuration shall be used to return road users to their normal path. The termination area shall extend from the downstream end of the work area to the last temporary traffic control device, such as END OF ROAD WORK signs, if posted (FHWA, 2009).

RESEARCH METHODS

A case study approach of research design was adopted in this study because Thika Superhighway, being the first superhighway to be built in Kenya, would be ideal in exemplifying the impact of the planning phase on the success of future mega projects. Purposive sampling was used since the main focus of the study was on in-depth information analysis, which dealt only with officers that worked on the Thika Superhighway (key informants). The key informants include; the Employer (Kenya National Highways Authority), Traffic Police, Design Engineers (APEC Consulting Engineers Limited), the umbrella body of resident associations in Kenya (KARA), and the Contractors (China Wu Yi / Sino Hydro / Shengli) who had been directly involved in the project. The researcher also sought to obtain information from the residents living along the highway who were directly affected by construction of the superhighway, especially with regard to road safety. Stratified random sampling was therefore used. The superhighway was divided into three lots, and simple random sampling was used within each lot to obtain a sample size which was representative of the whole population, and so that each resident had an equal chance of being selected.

Primary data was collected through direct interviews, focus group discussions and questionnaires. This data helped to evaluate whether the planned road safety measures were adequately implemented, given that evidence from the research conducted by the umbrella body of resident associations, between August and September 2011, indicated that residents kept raising the same concerns as had been factored in during the planning phase. Direct observation and photography were also incorporated to find out the impact of failure of appropriate planning and plan implementation on mega infrastructure project. For purposes of data analysis, Ms Excel, a computer program used for statistical analysis, was used. The data so analyzed was presented in form of line graphs and plates.

RESULTS AND DISCUSSION

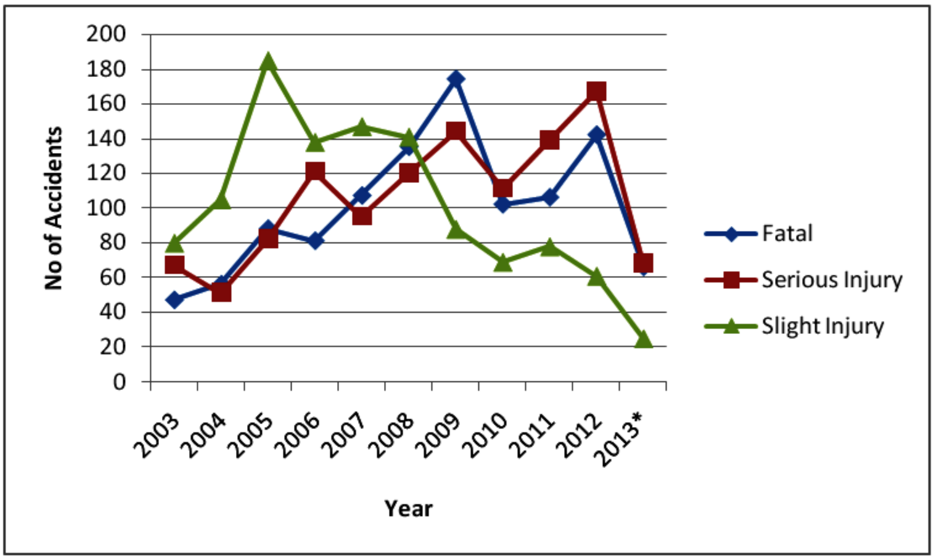
Period prone to most accidents

The period between construction and pre-opening of the Thika Superhighway witnessed the highest number of accidents. This is because immediately after construction commenced, most road users did not know how to use the road, which at the same time was being constructed. Motorists continued driving at high speeds oblivious of the hazards they were exposing themselves to, such as; open excavations, construction materials and other waste, e.g., mountains of soil and construction equipment left on the road work zones. The pedestrians also crossed the high speed highway at non-designated areas, risking being knocked down by the speeding motorists. The commencement of construction in the year 2009 was, therefore, characterized by an increase in accidents. This is illustrated in **Figures 4** and **5**. With time however, road users became aware of the hazards they were exposed to and adjusted accordingly, for example, motorists reduced vehicle speed and the number of accidents started going down.

Upon opening up of the road to the public in the year 2012, drivers were speeding through the densely populated areas, simply because it was now a highway. The service lanes on both sides were also not marked, and it was obvious some motorists were not aware that the service lanes were two-way lanes, for which reason they drove recklessly, thus endangering the other road users. This is a clear indication of inadequate traffic enforcement and failure to carry out safety awareness programmes during the implementation of the project, and upon re-opening of the road to traffic.

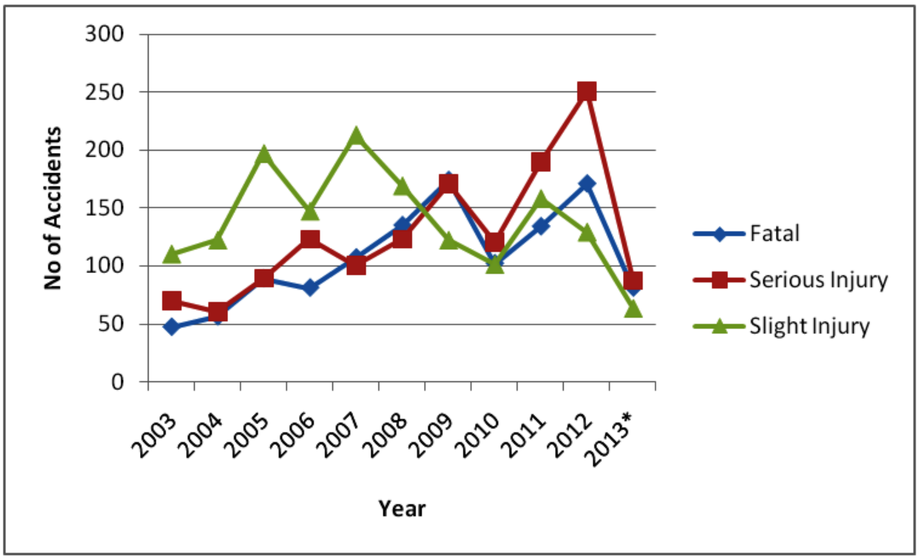
Some of the accidents were also attributed to the design of the highway. For example, the distance provided in weaving, merging or diverging in carriageway was insufficient to perform safe maneuver. This induced deceleration and acceleration on the carriageway instead of auxiliary lanes, induced sudden lane change and vehicle entering free flow with unsafe gaps, and increased risk of vehicle encroaching in the gore area or losing control. This is illustrated in **Plate 1**. There were no designated spots where motorists could pull over in case of mechanical problems or other emergencies. This was bound to lead to accidents as vehicles on high speed could easily ram on to the stationery vehicle. The inadequate signage and traffic safety management system on the road, especially for diversions, had also been blamed for the numerous accidents. This is a clear indication that some of the implemented designs did not comply with the international design standards.

PLATE 1
Insufficient weaving length
Source: Field survey 2015



***Key:** 2013* - data up to end of May 2013*

FIGURE 4
Cumulative accidents and severity – Lot 1
Source: Field survey 2015



***Key:** 2013* - data up to end of May 2013*

FIGURE 5
Cumulative casualties and severity – Lot 2 & 3
Source: Field survey 2015

The footbridges, some of which had now been installed, were too far apart, with some densely populated locations with high human traffic having no footbridges. Many pedestrians, after alighting from commercial vehicles, found it bothersome to access the footbridges. They just walked or ran across the highway. This increased the incidences of pedestrians being knocked down. The presence of guard rails and barriers increased risk of fall when crossing the multiple high speed lanes. This is illustrated in **Plate 2**. It was also difficult for the disabled to cross from one side of the highway to the other since they had challenges in using the footbridges, and could also not cross the highway without risking being knocked down by speeding motorists. The footbridges should, therefore, have been placed in the densely populated areas where there was high human traffic. This therefore demonstrates that the implementation of the designs did not factor the safety of all road users, in line with the international design standards. This is also a clear indication of the failure to include all the stakeholders during the planning phase of the project, where such issues, such as where footbridges would have been placed, could have been discussed. There was also inadequate traffic enforcement and failure to carry out safety awareness programmes by the relevant authorities.

PLATE 2
Pedestrians crossing at non-designated areas
Source: Field survey 2015

From the above, some of the planned road safety measures were not adequately implemented. This was so because either the road safety measures did not match the road users' safety requirements, or did not comply with the international design standards. The misplaced priorities can be attributed to the failure to include all the stakeholders during the planning phase of the project. For example, the location and number of footbridges was a concern. The respondents were of the opinion that footbridges were placed in sparsely populated areas, such as near Mang'u High School, instead of densely populated areas, such as Juja where Non-Motorized Transport had to use the same overpass as motorized transport. This, therefore, exposed pedestrians on the densely populated parts of the highway to the danger of being knocked down when crossing the high-speed highway. The poor human behaviour can further be attributed to inadequate traffic enforcement and failure to carry out safety awareness programs.

The distance provided for weaving, merging and diverging was insufficient for safe maneuver of vehicles, hence compromising safety of road users. The materials used for signs also did not have appropriate visibility, especially at night. Road safety audits were planned for at the planning, preliminary and detailed design phases, work zone, construction and pre-opening phase, but when it came to implementation, the audit at the construction phase was omitted. The planned road safety measures were not adequately implemented, therefore did not comply with the best practice.

CONCLUSION

In summary, the research findings were that some of the planned road safety measures were not adequately implemented. This was either because the road safety measures did not match the road users' safety requirements, or did not comply with the international design standards. This is an indication of failure by the planners to utilize available information. There was also failure by the planners to identify and use an appropriate design manual, and to identify innovative ways of addressing safety issues, which were bound to come up within the limitation of finances and space. There was also failure to include all the stakeholders during the planning phase, who would have raised some of the safety issues which were likely to occur. This led to implementation of designs that did not meet the international design standards. The poor human behaviour due to inadequate traffic enforcement, and failure to carry out safety awareness programmes by the relevant authorities during the implementation of the project and upon re-opening of the road to traffic, also meant increased accidents on the highway.

From the foregoing, failure to consider road safety measures during the planning phase can have serious repercussions throughout the various phases of a road construction project, especially the implementation phase. This can be exemplified by the road safety challenges on the Thika Superhighway, such as frequent accidents, particularly on the densely populated parts of the highway. People with disabilities, such as the blind and disabled, were not taken into consideration in the design and implementation of the project, it was therefore difficult for the disabled to cross from one side of the highway to the other without risking being knocked down by speeding motorists. There were also no provisions for cars that broke down or ran out of fuel while on the highway and needed to pull aside to fix the problem. This was bound to lead to accidents, as vehicles at high speeds could easily hit the stationary vehicle. This further confirms the research proposition that the road safety measures identified during the planning phase were not adequately implemented, leading to increased accidents on Thika Superhighway.

RECOMMENDATIONS

The study recommends that there is need for more engagement by professionals to make government officials and practicing engineers more aware of the need for context sensitive road-building (getting input from users and those affected by the road prior to design and construction), and of their responsibilities in designing safe roads.

Public participation and stakeholders' engagement should be taken into consideration right from the planning phase of road infrastructure projects, in line with the Constitution of Kenya (2010), including a series of road safety awareness-creation initiatives and public events to educate citizens on highways and transportation plans and policy.

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