Supervision tool for road infrastructure projects with KoBoToolbox: case of the Yaoundé - Bafoussam road

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Abstract:

Context: With the objective of achieving its emergence by 2035, the State of Cameroon has initiated numerous projects such as road and highway projects, the construction of stadiums, multimodal platforms and ports. To achieve this, the construction of such infrastructures must go through a quality control and monitoring to meet international standards, especially for road projects. However, this monitoring becomes difficult or ineffective in times of health crisis, and the question arises as to how to continue the control and monitoring of road projects in the event of total or partial restriction or containment. summary of your article. It should concisely describe the contents of your article, and include key terms. It should.

Objective: Development of a cartographic tool for remote supervision of road infrastructure projects based on a multifunctional database using the KoBoToolbox software.

Material and method: Analysis of the possibilities offered by the Kobotoolbox software, the collection of data in the field by means of GNSS receivers, smartphones and interviews with the monitoring mission of the case study, the presentation of the processes of processing and analysis of the acquired data as well as the presentation of the software that contributed to the collection and processing of the said dataKoBoToolbox.

Results: Implementation of a remote supervision platform consisting of a database supported by an interactive information exchange tool.

Conclusion: This platform should make it possible to monitor the activities of the on-site workshops (industrial base), the topographic work, the geotechnical studies, the progress of the work already carried out in the field, as well as the mapping of the various crossing structures already built.

Keywords: remote supervision, road infrastructure, mapping.

List of abbreviation

GEMS: Geo-Enabling for Moitoring and Supervision.
WB: World Bank.
ADB: African Development Bank.
PSOD: Private Sector Operations Department.

PMP: Project Management Professional.
ASR: Annual Supervision Report.
RTK: Real Time Kinematic.
GJSD: Growth and Jobs Strategy Document.
GNSS: Global Navigation Satellite System.
ISO: Open System Interconnexion.
MC: Mission Control.
GIS: Geographic Information System.

Introduction

The government of Cameroon has set itself the objective of becoming an emerging country by 2035. To do so, several ministries have voted the Growth and Employment Strategy Paper (GESP) which subdivides, presents and details the different priority investment programmes that will allow the state of Cameroon to achieve its objectives by 2035, one of the most important is the investment in the development of road transport infrastructures, thanks to its flexibility and accessibility, Road transport is the main mode of movement of goods and merchandise, in fact, the note on the transport sector mentions that road transport ensures nearly 90% of the domestic demand for passenger transport and nearly 70% for the transport of merchandise, the said note also presents the failure of the Cameroonian road network due to the large number of unpaved roads compared to the number of paved roads (Kabanguka et al. , 2015). It is clear that more investment programmes in the road transport sector are to come with the asphalting of roads, which will create an intensification of investment in this sector. In order to carry out these road transport sector projects, good supervision and monitoring are important; unfortunately, this is not so much the case, as the Covid-19 pandemic has made this shortcoming clear.

Indeed, it was difficult to carry out the supervision of this project given the barriers and distancing measures that were in place, which clearly highlighted the failure of the traditional supervision system that requires a full physical presence of the supervision teams and the teams to be supervised on site, as most of them are technically made and driven. There was a reduction in the number of staff deployed on this project, which made monitoring inefficient, as it was very difficult with the health restrictions in place, so to compensate for this the notion of teleworking was born and it spread very quickly around the world; but this alternative required a good internet connection with good speed which was not very often the case as the majority of the world's population used this alternative which overloaded the network.

The PMP noted that most projects do not fail because of lack of investment, but because of poor monitoring; it is therefore important for the government of the Republic of Cameroon to put emphasis on quality monitoring of all its road projects, especially the Yaounde-Bafoussam road project because of its strategic importance, this road is part of the national triangle network and accounts for the majority of the country's economic activities

The question arises as to how to continue the control and monitoring of road projects in the event of total or partial restriction or containment. It is in this sense that this work consisted in the development of a cartographic tool for remote supervision of road infrastructure projects articulated on a multifunctional database with the KoBoToolbox software as support.

The methodology used for this work consisted of the analysis of the possibilities offered by the Kobotoolbox software, the collection of data in the field followed by interviews with the monitoring mission of the case study, the presentation of the processing and analysis of the acquired data as well as the presentation of the software that contributed to the collection and processing of the said data.

Methodology

1. General site survey

The site visit will take place at the Mission De Contrôle (MDC) of the Yaounde-Bafoussam road project, namely SAFEGE Afrique Centrale, and the lot that has been chosen for data collection is number two, namely Kalong - Tonga, the main town where the MDC and the road project company are located.

This town is located in the central region, the department of Mbam-et-Inoubou, and includes the Babitchoua, Baloua, Bafangs, Bagangtés, Bétis, Bamouns peoples, who have settled in successive waves, each claiming to be native to the said locality. This ethnic variety is the result of the various migrations that have affected the locality (wikipedia, 2022).

Also, with its mild climate, this locality is distinguished by its numerous economic and geological resources. The main economic activities of Makénéné are trade and agriculture (coffee, potatoes, maize and beans); as for the geology, we can distinguish mainly the high-grade metasedimentary series found between Bafia and Obala, the paleo-proterozoic series in Tonga and the Gneiss and amphibolic series in Bafoussam (Nzenti et al, 2010).

2. Procedure

This section will detail the three steps mentioned above.

i. Presentation of KoBoToolbox:

- The creation and exploration of the Kobo account: it will be a question of creating an account via the url www.kobotoolbox.org and activating it via the link communicated by the Kobotoolbox by email. Once created, an inspection of the account will be made to know the different possibilities it offers**;**

- The establishment of the question database: it will pass by the parameterization of the metadata by selecting all their box and save them. Afterwards, a new form will be created and a different number of questions of various types (point, date&time, text, photograph, video, audio, numbers, calculation...) will be added to it. Once this has been done, the text questions will be set up with a choice of answers, the others will have a single answer and each new question will be added to the library which, at the end of this procedure, will constitute the database.

ii. Data acquisition:

- The interviews: they consisted in knowing the functioning of the control mission for a road project, to know the role that each actor plays and to have the opinion of each one on the implementation of a cartographic tool for remote control of road projects in Africa, particularly in Cameroon;

- Deployment of the questionnaire: this consists in sharing the data of the database so that they are filled in with information. This sharing can be done via a url or on a smartphone with KoboCollect/ODK Collect available on play store;

- Data collection: the aim is to provide information on the various activities taking place on the site by recording the location of each activity using a GNSS receiver. Once the information has been collected, it will be submitted to the Kobo account administrator. This was done thanks to the follow-up sheets of the Yaounde-Bafoussam road project control mission.

iii. Data processing and analysis:

- Data export: once the data collected in the field is redirected to the Kobo account, it is a matter of exporting it in XLS format compatible with the Excel spreadsheet;

- **Data cleaning**: each piece of information collected is separated into an Excel sheet in order to carry out the operations that will allow the analysis of the data.

- Data analysis: in order to analyse the information collected in the field, statistical calculations will be made for each of the activities that took place on the site, and then this evolution will be represented on a graph (a curve or a diagram).

Results

1. The question database

The steps from the creation of the Kobo account to the creation and editing of a new form allowed for the creation of a database of questions that would allow for the control and monitoring of on-site activities; in order to have a spatially referenced database, the concept of location had to be integrated and this was done through the addition of point and image type questions that allow the account administrator to have a fixed idea of the location of each on-site activity.

2. The industrial base

The results obtained at the industrial base mainly concern the reinforcement work, formwork and casting of prefabricated work elements (gutters, channels, concrete ditches, etc.). These results are recorded in a table and a diagram explains the information already provided in the table. The monitoring of this activity has thus revealed that 22% of the activities of the industrial base have been completed, 64% are in the process of being validated, 14% are expected to be completed and 0% have not been completed.

3. Topographic work

The results concerning the monitoring and evolution of the topography work were based essentially on the reception of polygonal calculations (main and secondary), levelling work, the addition of milestones and the reception of the calculation report of the latter, the various implantation works (earth entry and structure). The monitoring of this activity has thus revealed that 22% of the surveying activities are completed, 50% are in the process of being validated, 13.75% are expected and 14.25% are not carried out.

4. Geotechnical works

The results of the monitoring and progress of the geotechnical works were based mainly on the sampling of specimens for crushing tests, concrete formulation studies, acceptance of the excavation base and the identification of materials. The monitoring of this activity has thus revealed that 35.4% of the geotechnical activities have been completed, 42.2% are in the process of being validated, 15.4% are expected to be completed and 7% have not been completed.

5. Monitoring the progress of the work

The results of the monitoring and progress of the work were based mainly on the progress of the construction of the control mission laboratory, the installation of the asphalt mixing plants and the cement concrete plant. The monitoring of this activity thus revealed that the construction work on the control mission laboratory is 70% complete, that of the asphalt mixing plants 75% and that of the cement concrete plant 85%.

Discussion

The work focused on the use of KoboToolBox for monitoring the rehabilitation of the Yaounde-Bafoussam road, which had the objective of contributing to the development of a cartographic tool for remote supervision of road infrastructure projects with KoboToolBox, which will allow for permanent monitoring of the progress of work on site.

Indeed, the Yaoundé-Bafoussam national road has been in a fairly advanced state of deterioration and has seen an increase in the number of road accidents. The choice of KoboToolBox is justified not only by its capacity to manage information of various kinds (text, images, videos, coordinates, etc.), but also by its main financial backer, the AfDB.

The main objective of this study was to set up a remote supervision platform consisting of a database supported by an interactive information exchange tool that will allow the remote and permanent monitoring of any road project

in times of crisis. This is a reliable, secure and efficient way of monitoring projects in the event of a crisis, a reduction in the number of people in the field or an abrupt demobilisation of the monitoring mission.

This research mainly targeted the activities of the workshops on site (reinforcement work, formwork, casting, demolition of structures and development of diversions); topography work (planimetric and altimetric survey, establishment of earth entrances, gutters and structures, delimitation of the project's right-of-way, etc.); geotechnical studies (identification of aggregates and other materials, crushing tests, concrete formulation, etc.) and the progress of work. All of this was done to effectively supervise the road project and allow for the detection of potential delays. Most of the processing was done in Excel except for the coordinates and images which were done in KoboToolBox. Nevertheless, KoboToolBox also allows the processing of the data that were processed in Excel, which makes the remote supervision process automatic, so it would be necessary to think in future research about associating this remote supervision tool with a Geographic Information System (GIS), which would reinforce this tool in the analysis and decision support on a geographical and multi-temporal scale for the specialists in the field
In the course of the work carried out, a database of issues supported by a remote supervision mapping tool was set up, thus constituting a real interactive tool for information exchange.

Thanks to this tool, several activities were monitored and by comparing the dates of completion of each activity with those of the activity timetable, it emerged that the road project linking the city of Yaounde to that of Bafoussam in Cameroon was delayed, which demonstrates the reliability of the project. Interviews with members of the administration and the construction and control companies revealed that this delay is due to the administrative slowness of the call for tenders.

Also, in view of the large number of possibilities of visualisation of the kobotoolbox data, it is possible for the supervisor to easily find his way in time, space and place, respectively through the date & time, photograph and video and point data which show on a map the place of each activity and allow to have the geographical coordinates of the works to be realized.

Declarations

Conflicts of interest

The authors declare no conflict of interest.

Funding Statement

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Administrative authorization

Concerning the collection of monitoring data, the researcher received authorisation to collect data from the monitoring mission represented here by SAFEGE Afrique Centrale. The researcher also received authorization to collect data from the Cellule des ProjetsRoutiers à Financement Conjoint BAD/BM of the MINTP.
Transport (MINT). A copy of all these authorisations can be made available if required.

Contributions of the authors

WOUNBA Jean Francois, ELIME BOUBOAMA Aimé and NKENG George ELAMBO contributed to the design of the study.

ALYOUM HAOUSSA contributed in critical reading.

MVONDO FANGA Aubin Loïc contributed to the statistical analysis and writing of the manuscript.
All authors read and approved the final version of the manuscript.

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What is known about this topic

Most projects do not fail because of lack of funding but because of poor follow-up, which is generally due to a demobilisation of the MDC when the company it represents registers a number of unpaid invoices.

What your study provides

This study provides:

-A new and secure approach to monitoring road projects.
- The deployment of a reduced team of field control missions in times of health crisis and the reinforcement of the office teams in teleworking.

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Figure 1. Overview of the database set up on Kobot Toolbox

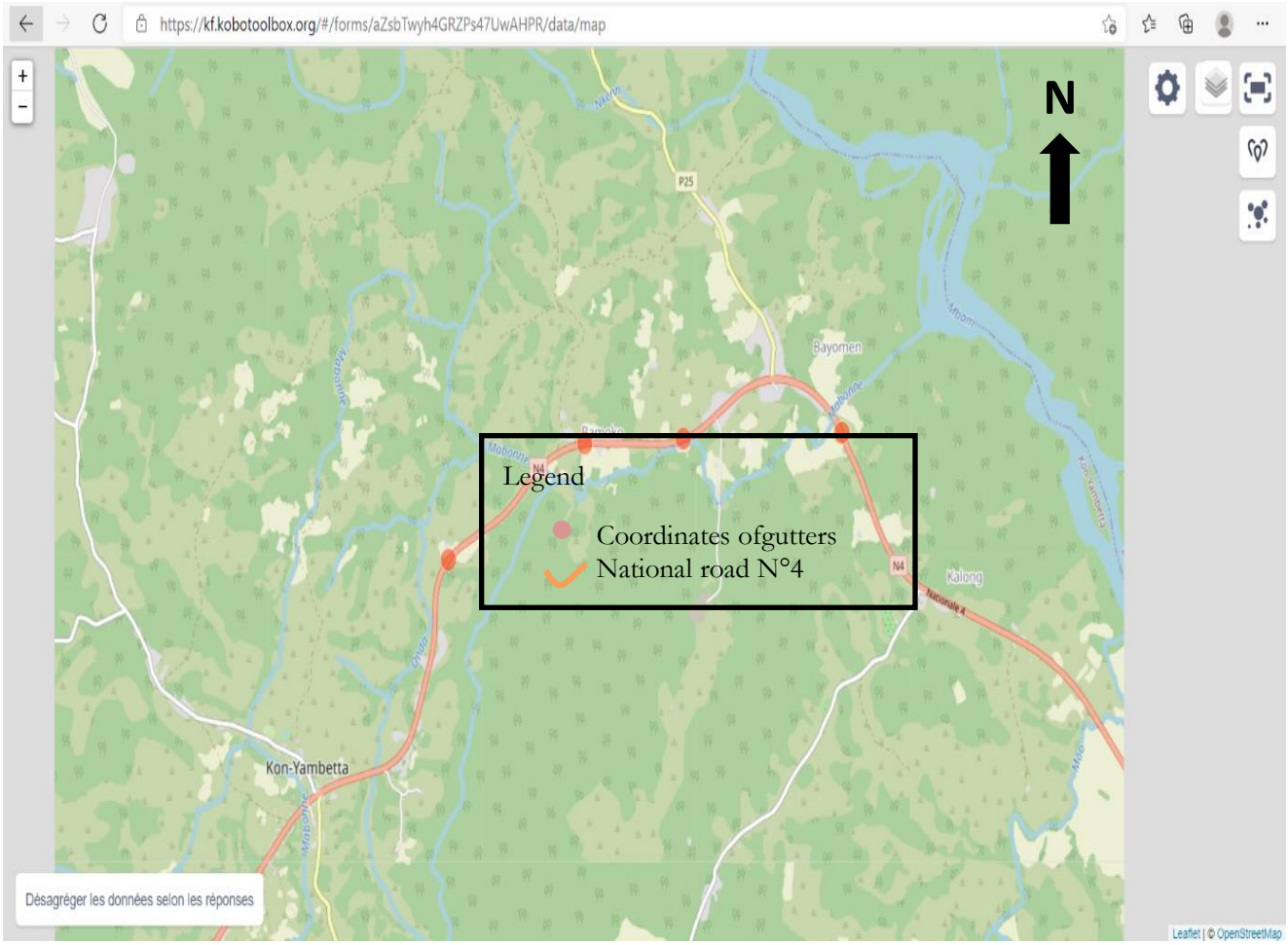

Figure2. Result of the coordinates of the first completed gutters

Result industrial base

Table 1. Result of data collection for reinforcement of gutter elements

Date	Reinforcement of prefabricated gutter elements 1x1	Percentage
03-may	In progress	56%
09-may		
16-may		
24-may		
06-june		
09-june	Expected	22%
11-june		
13-june	Completed	22%
28-june		
Total		100%

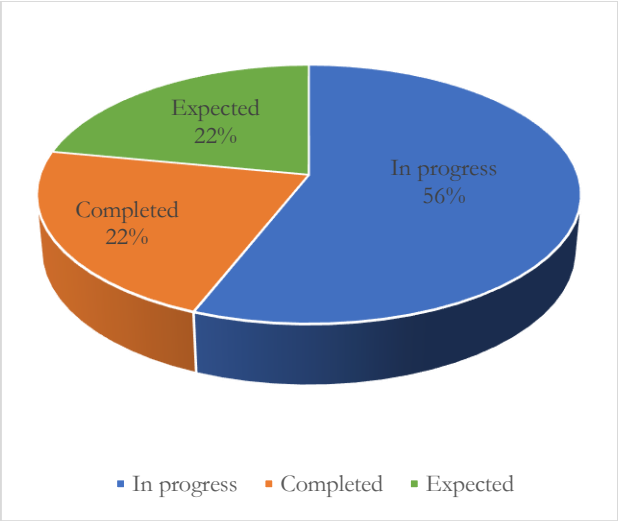

Figure 3.Progress of reinforcement work on the gutter elements at KP6+455 and KP6+555

Tableau 2. Result of the data collection for the formwork of 1x1 prefabricated gutter elements

Date	Coffrages des éléments dalots préfabriqués 1x1	Pourcentage
03-may	In progress	44%
09-may		
16-may		
24-may		
06-june	Expected	33%
09-june		
11-june		
13-june	Completed	22%
28-june		
Total		100%

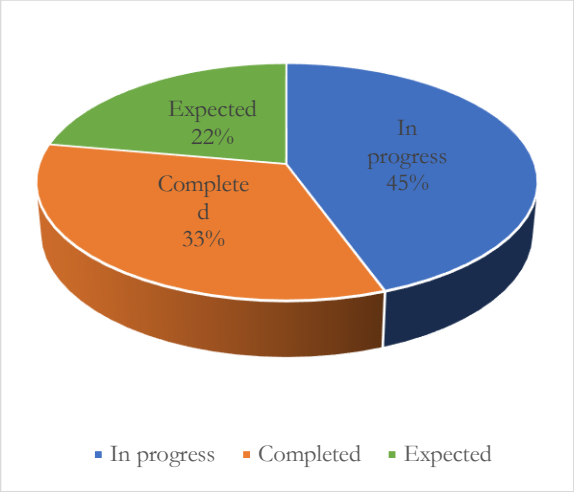

Figure 4. Progress of the formwork for the elements at KP6+455 and KP6+5551x1

Table 3. Result of the data collection for the casting of 1x1 prefabricated gutter elements

Date	Gluing of prefabricated gutter elements 1x1	Percentage
03-may	In progress	78%
09-may		
16-may		
24-may		
06-june		
09-june		
11-june		
13-june	Completed	22%
28-june		
Total		100%

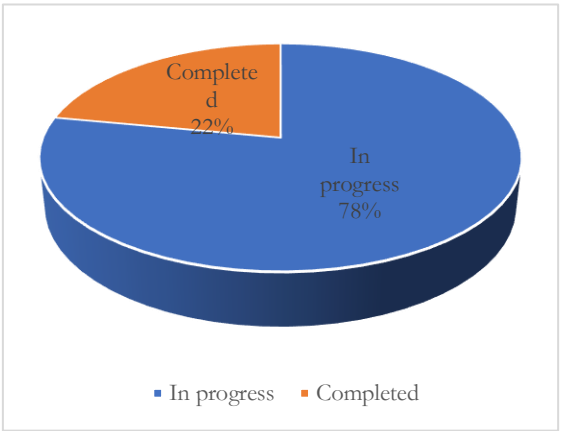

Figure 5.Progress of the casting of the 1x1 gutter elements at KP6+455 and KP6+555

Results of the topographic work

Table 4. Result of the data collection for the reception of the secondary polygonal

Date	Reception of the secondary polygon from KP00 to KP46	Percentage
03-may	In progress	33%
09-may		
16-may		
24-may	Expected	33%
06-june		
09-june		
11-june	Completed	33%
13-june		
28-june		
Total		100%

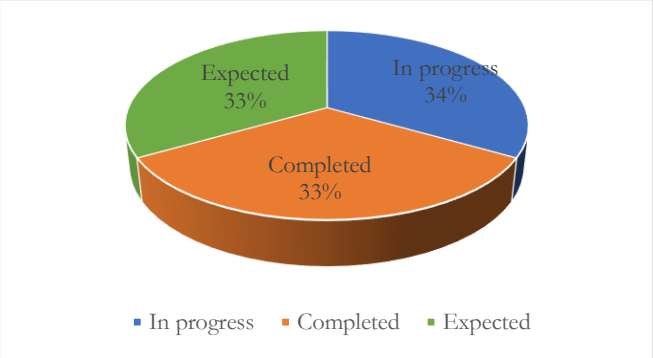

Figure 6. Progress of secondary polygonal work

Table 5. Result of the data collected during the levelling works

Date	Levelling from KP00 to KP11	Percentage
03-may	In progress	44%
09-may		
16-may		
24-may		
06-june	Expected	22%
09-june		
11-june	In progress	11%
13-june	Completed	22%
28-june		
Total		100%

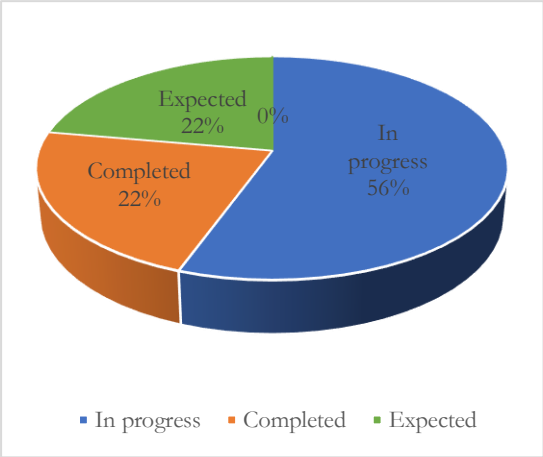

Figure 7. Progress of the levelling work

Table 6. Result of data collection when adding terminals from KP57+200 to KP64+400

Date	Addition of new terminal from KP57+200 to KP64+400	Percentage
03-may	In progress	67%
09-may		
16-may		
24-may		
06-june		
09-june		
11-june	Completed	33%
13-june		
28-june		
Total		100%

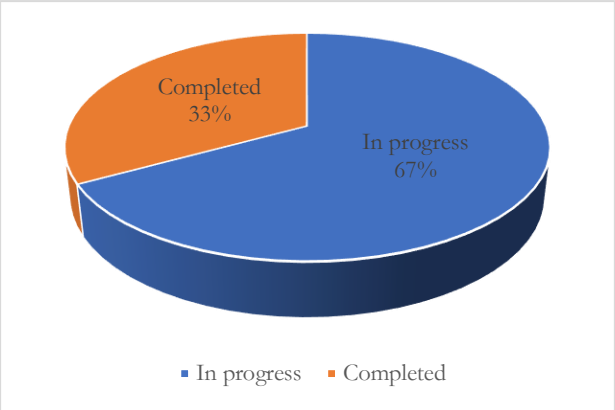

Figure 8. Progress of the work to add bollards from KP57+200 to KP64+400

Table 7. Result of the data collection of the driveway implementation works

Date	Layout of the earth entrances at KP2+252 and KP3+395	Percentage
03-may	Not done	22%
09-may		
16-may	Expected	22%
24-may		
06-june	In progress	56%
09-june		
11-june		
13-june		
28-june		
Total		100%

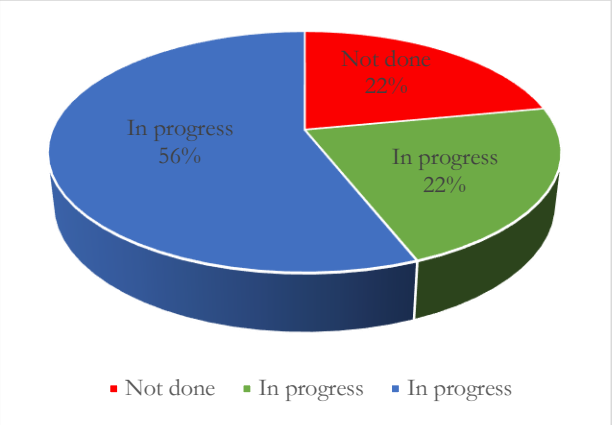

Figure 9. Progress on the implementation of the earth entrances

Geotechnical activities

Table 8. Result of the follow-up of the crushing test of concrete specimens

Date	Sampling of specimens crush tests	Percentage
03-may	In progress	33%
09-may		
16-may		
24-may	Expected	33%
06-june		
09-june		
11-june	Completed	33%
13-june		
28-june		
Total		100%

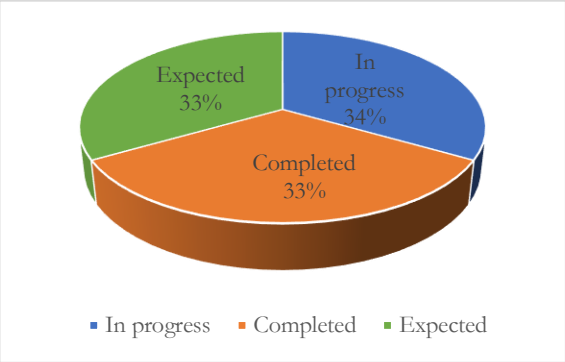

Figure 10. Progress of the concrete crushing test work

Table 9. Result of the monitoring of the concrete formulation work

Date	Concrete design study	Percentage
03-may	In progress	56%
09-may		
16-may		
24-may		
06-june		
09-june	Expected	22%
11-june		
13-june	Completed	22%
28-june		
Total		100%

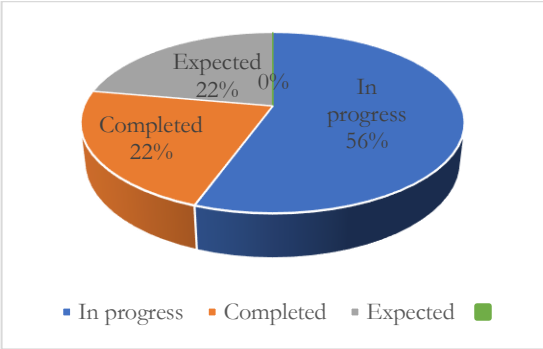

Figure 11. Evolution of concrete formulation work

Table 10. Result of the monitoring of the excavation reception works

Date	Reception of the bottom of the excavation at KP2+562 and KP4+023	Percentage
03-may	Not done	33%
09-may		
16-may		
24-may	In progress	11%
06-june	Expected	22%
09-june		
11-june	Completed	33%
13-june		
28-june		
Total		100%

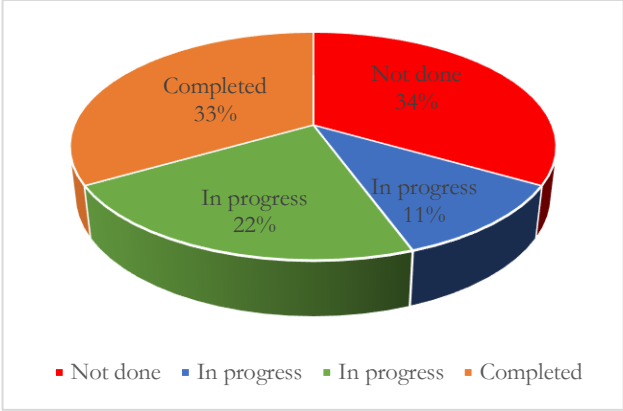

Figure 12. Progress of the acceptance work on the bottom of the excavation

Table 11. Results of the follow-up work on the identification of lateral loans from KP00 to KP04

Date	Identification of lateral loans from KP00 to KP04	Percentage
03-may	In progress	44%
09-may		
16-may		
24-may		
06-june	Completed	56%
09-june		
11-june		
13-june		
28-june		
Total		100%

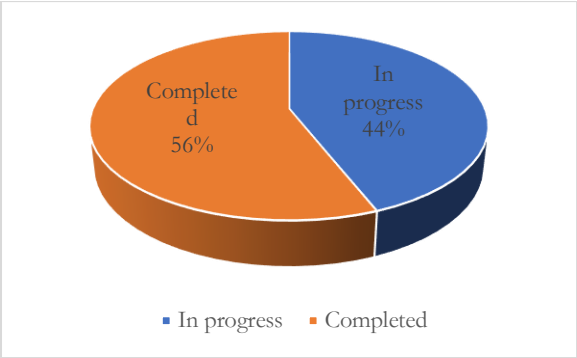

Figure 13. Evolution des travaux d''identifications des emprunts latériques

Table 12. Results of the monitoring of the aggregates identification work

Date	Identification of aggregates from KP00 to KP04	Percentage
03-may	In progress	67%
09-may		
16-may		
24-may		
06-june		
09-june		
11-june	Completed	33%
13-june		
28-june		
Total		100%

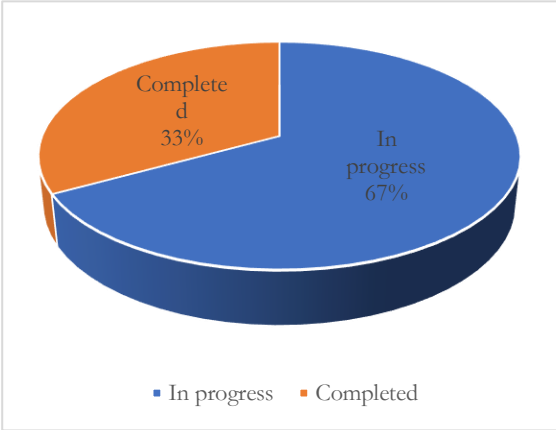

Figure 14. Progress of aggregates identification work

Monitoring the progress of the work

Table 13. Results of the data collected at the construction of the CM laboratory

Date	Laboratory of the control mission
03-may	5%
09-may	5%
16-may	10%
24-may	20%
06-june	25%
09-june	35%
11-june	45%
13-june	70%
28-june	70%

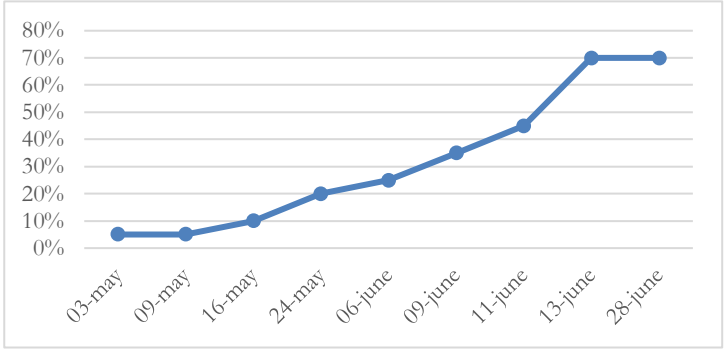

Figure 15. Construction progress of the CM laboratory

Table 14. Result of the data collection for the installation of the asphalt mixing plant

Date	Installation of the asphalt mixing plant
03-may	35%
09-may	35%
16-may	35%
24-may	35%
06-june	50%
09-june	50%
11-june	75%
13-june	75%
28-june	75%

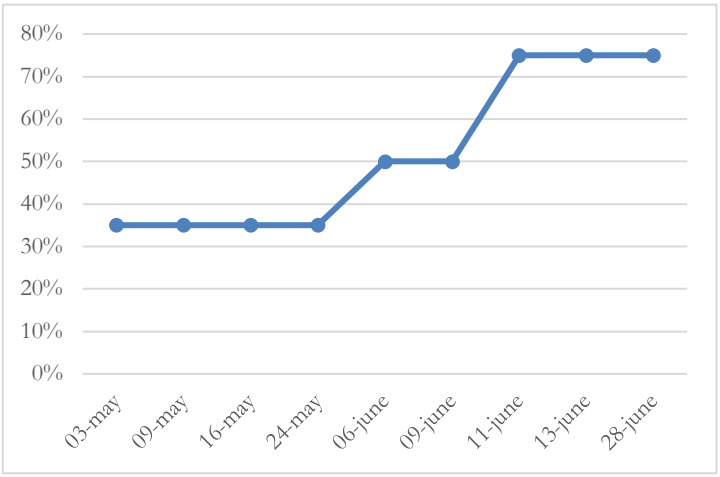

Figure 16. Progress of asphalt plant installation work

Table 15. Results of the data collected at the concrete cement plant

Date	Installation of the cement concrete plant
03-may	70%
09-may	70%
16-may	70%
24-may	75%
06-june	80%
09-june	85%
11-june	85%
13-june	85%
28-june	85%

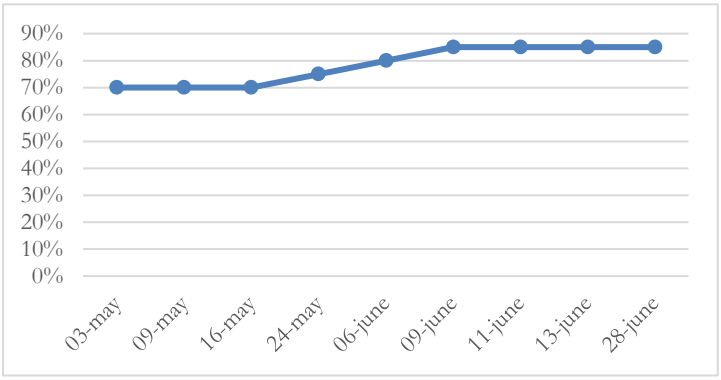

Figure 17. Progress on the installation of the cement concrete plant