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ORGANIZATION OF THE HIGHWAY STRIP REPAIR PROCESS

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Abstract

The article presents the possibilities of advance development of detailed organization-technical plans for the repair of Highway Strips, which will enable their effective use, particularly during combat operations – while maintaining the required time and technical standards at the same time. The main objectives of Highway Strips were presented; their role in securing military aviation activities and historical conditions for their creation. The concept of HS (Highway Strip) was defined along with the modern principles for their construction, modernization and renovation. Based on a selected example, the principles for evaluating the technical condition of their pavement and the repair possibility assessment were presented. At the same time, typical damage to HSs and factors affecting such damage were presented. Next, the methods and technologies for repairing various types of bituminous pavement damage repairs were discussed, with particular emphasis on the methods of repairing cracks, surface damage, deep damage and asphalt renovation. A schedule for the "Wielbark" highway strip was also developed, and the necessary calculations of the repair times, as well as the resources and resources for securing these operations were made. The article is concluded with a short summary and a proposal for further work, aimed at inhibiting the destructive processes of Highway Strips in Poland.

Keywords: *Highway strip, airfields, airstrips, runway repair processes*

1. Introduction

Military aviation comprises all kinds of aircraft, air personnel and airfield infrastructure, without which there would be no possibility to conduct aviation operations. Airfield infrastructure is very important, though it requires very large financial resources, and its execution is complicated and time consuming. For these, among others, reasons, various types of roads (motorways) are used for the construction of the so-called highway strips (HS). It is most often executed during the construction of motorways, express roads, which significantly decreases the construction costs of airfields and the entire airfield infrastructure. A highway strip (HS) is a public road section adapted for take-off and landing of military aircraft. It is usually a four-lane road section, most usually through a forest, adapted for take-off and landing of military aircraft [14]. Both ends of the runway contain widened sections, forming so-called aircraft aprons (AA). There are currently 21 highway strips (HS) in Poland (which are not subject to the classified information clause) – see Fig. 1. Out of the 21– due to its technical condition – only the "Kliniska" strip may be deemed an active HS. It is located north of Wielgowo, on a provincial road no. 142. It was constructed already in the 1930s by Adolf Hitler, therefore, its history dates back to before World War II. The last aircraft landed here over 10 years ago. The second strip, with its technical condition not raising reservations and enabling its immediate use, was recently constructed on the

A4 motorway, between the Tarnów Północ and Dębica Wschód nodes– Fig. 2. The condition of the other strips is neglected, and the ones with vehicle traffic undergo additional, accelerated erosion, which causes ruts, blocking the possibility of a failure-free aircraft landing.

Fig. 1 Road map of highway strips [15]

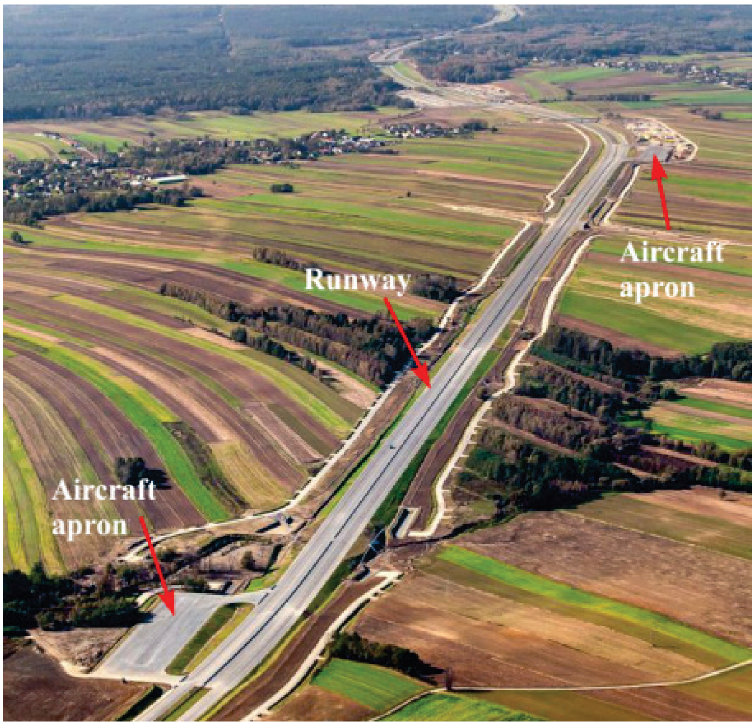

Fig. 2. View of a highway strip on the A4 motorway. Source: developed using a photo from [16]

Such a state of affairs requires in-depth analyses, mainly aimed at determining the possibilities of improving their technical condition, which would enable their use, both for training in time of peace, as well as emergency landing during combat operations. One of the most important issues in this field is the determination of the possibility of a fast and efficient refurbishment of highway strips in combat conditions. The requirements of technical standards in this regard are less stringent, though highly dependent on their duration– we mean rather fast operations increasing the possibilities and the safety of aircraft landing. This raises a lot of doubt; however, due to the essence of the issue, it requires the execution of such analyses, at least to a general extent.

2. Highway strips– requirements

A runway is a critical element of the entire airfield. It is here, where the landing generates the greatest pressure forces induced by an aircraft mass and speed and the outflow of hot flue gases from jet engines. It is very important for pavements to be free from damage, cracks, and flaking. Any object left on a runway may pose a threat to a taking-off and landing aircraft. Even the smallest thing, when being sucked in to a turbo-jet engine will cause its destruction-failure, and in an extreme case, a very serious aviation accident or disaster. Such dangerous objects are in aviation known as FODs *(foreign object damage)* [17]. An airstrip should be also characterized by a high resistance, to not only loads, but also weather conditions. Taking care of artificial and turf pavements is very important in civilian and military airfields. In order to ensure the continuity of operation of Highway Strips, KOL (Airfield Support Company) receives appropriate technical parameters of these pavements, such as inter-bedding bonding, load bearing capacity, without which no aircraft would safely take-off and land. A runway is a hardened pavement (concrete, asphalt-concrete) with a width and length depending on the airfield reference code. The code means the minimum length required for the take-off of an aircraft with a MTOW [10].

A runway with a precision approach is 30, 45 or 60 meters wide. In order to enable safe take-off and landing, an airstrip is equipped with lights, and horizontal and vertical markings. The shoulder should be 130-150 m, depending on the type of accepted aircraft.

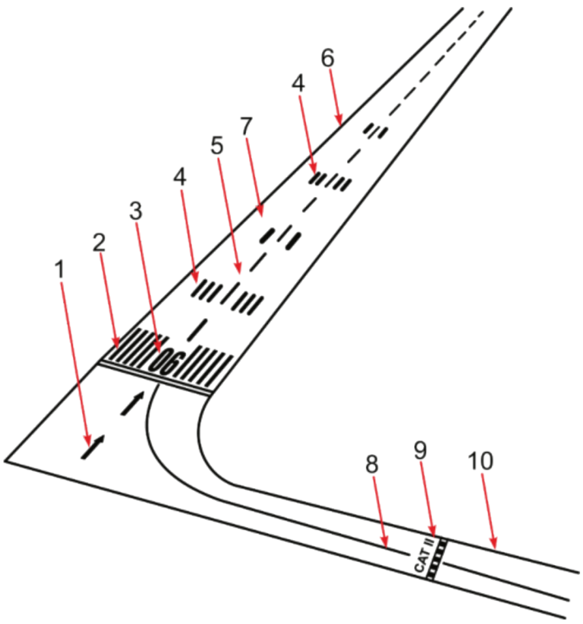

Fig. 3. Runway signs [7, 11]: 1 – person mark, 2 – threshold mark 3 – threshold identity mark, 4 – touchdown zone mark, 5 – take-off axis mark, 6 – runway edge mark, 7 – fixed distance mark, 8 – taxiing axis mark, 9 – waiting location prior to entering the runway, 10 – taxiing route edge

Horizontal markings of a highway strip are a part of just the threshold identity and strip axis marks (airstrip boundaries). A Highway Strip should enable, most of all, appropriate conditions for masking and be adapted for efficient command organization, including the technical and material supply. HS Wielbark has good masking properties, with forest on both sides, which provides airstrip camouflage (Fig. 4).

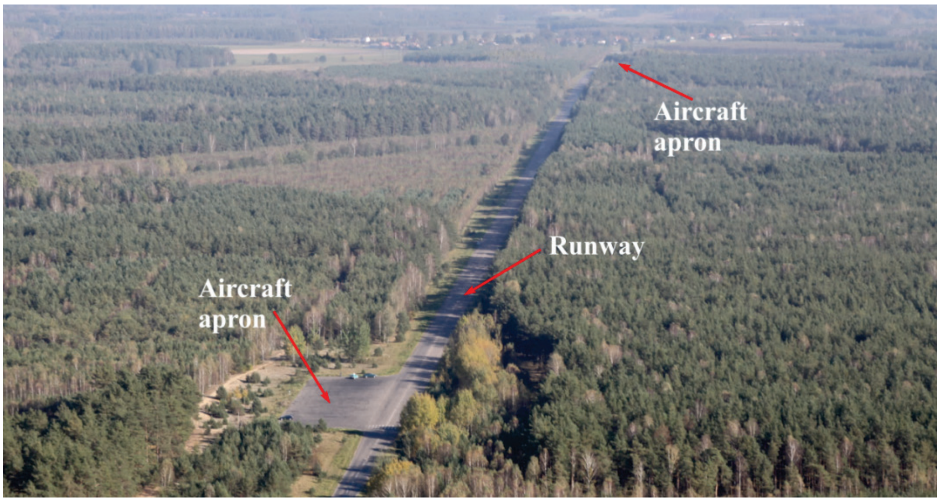

Fig. 4. HS – Wielbark. Source: developed using photos from [18]

HS Wielbark has a bituminous surface. The substances bonding the loose material into a compact mass, i.e., bituminous binder are divided into asphalt (natural and pet-related) and tar [19]. In this case, the sub-base it was created on plays a particularly important role. Durability depends on the technical condition of the substructure. Asphalt pavements are commonly used in aviation. The technical parameters of HS Wielbark are shown in Tab. 1.

Tab. 1. HS Wielbark technical parameters, source: own elaboration

No.	Landing area element name	Length [m]
1	Runway	2,200
2	Total width	24
3	Runway width	12
4	Apron parameters: width, length	30×100

Due to these parameters, it is mainly used for emergency landing (does not meet the primary basic parameters of HS II technical class, where the total width is 40 m, and runway width is 16 m). A diagram of the Wielbark Highway Strip is shown in Fig. 5.

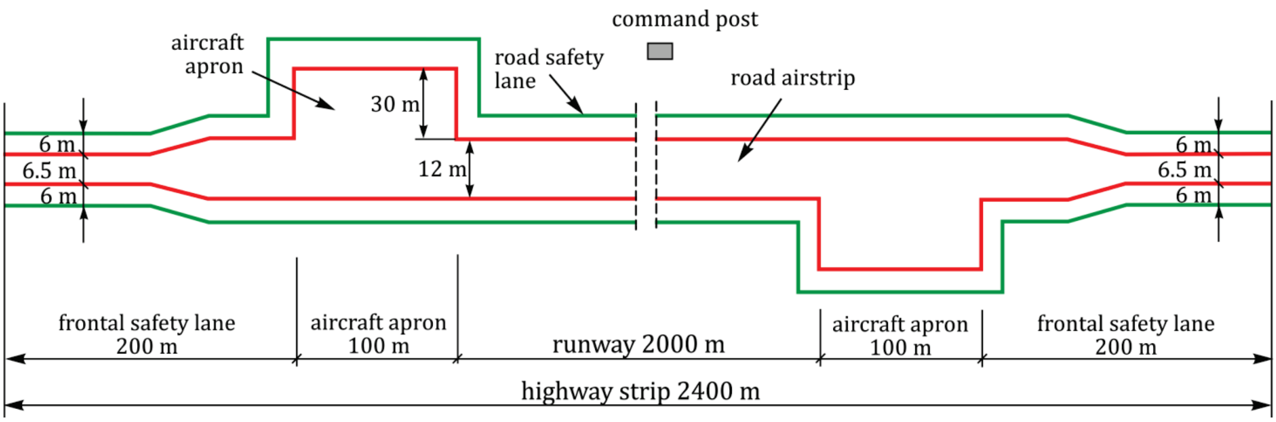

Fig. 5. Diagram of Wielbark Highway Strip. Source: own elaboration based on [9]

3. Runway pavement damage

The distribution of damage within the selected Wielbark Highway Strip is shown in Fig. 6. The most damaged elements of a road airstrip are the aircraft landing zones. The greatest damage within HS Wielbark is present on both sides of the airstrip, at around 200 m. The beginning of an airstrip is the most critical element of a runway, since it must resist the largest loads.

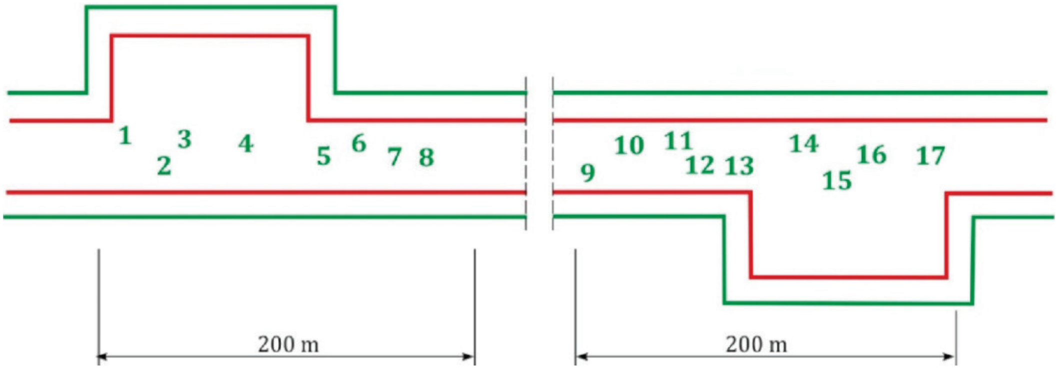

Fig. 6. Distribution of damage on the Wielbark Highway Strip. Source: own elaboration

The conducted observations and measurements of the damage identified at HS Wielbark enabled the determination of the scope of repairs necessary to restore its operational capacity. It should be noted that the basic criterion for selecting the method and scope of work is the safety of a taking-off and landing aircraft [5].

Repair of shallow losses (Fig. 7) are performed with the surface retreading method. Bituminous-epoxy spraying is used for this purpose, with the use of liquid asphalt also possible. Moreover, it is recommended to use mixtures, with the diameter of the largest grains being at least 2.5 times smaller than the depth of the losses– whereas, it is recommended no to use mixtures, with the largest grains bigger than 12.8 mm.

Bituminous-epoxy mortars and finished mineral-asphalt mixtures may be used for these repairs.

Fig. 7. Surface aggregate and binder losses [13]

The activities to be undertaken in order to repair surface damage, include:
- determining the extent and type of damage,
- preparing an adequate amount of labour and resources (materials),
- removing poorly bonded grains,
- thoroughly cleaning the identified damage.

A damaged surface is repaired through:
- cleaning the damaged location,
- priming (or spraying) the damaged location with asphalt,
- roughing with fine sand (with suitable grain size),
- cleaning loose particles from the repaired surface.

„Pavement surface repairs are aimed at – most of all – tightening the abrasive layer, improve its roughness, decrease aquaplaning.

Deep damage repairs (Fig. 8) concern locations exhibiting decrements in structural bondings – in the bituminous binder.

Fig. 8. Deep damage [13]

Start the repair process for damage of this type from:
- determining the extent and outline of the required patch,
- pavement cleaning,
- cutting the damage edge (by levelling and giving a simple shape),
- thorough cleaning and removing loose pavement particles,
- bottom drying.

The repair process may be executed with:
- a cold-applied ready mineral-asphalt mixture; all mixtures are thickened in layers (bottom – with a vibration plate, upper – with a steel roller or vibration plate),
- a bituminous-epoxy mortar (resistant to the impact of fuel),
- cast asphalt – it involves filling the prepared holes with cast asphalt.

Repairing cracks (Fig. 9) in an HS pavement is usually done through thoroughly cleaning identified gaps (together with the adjacent pavement – ca. 5 cm on each side of the crack). Then spread asphalt heated to a temperature of max. 140ºC over the gaps. The end stage involves removing potential edge chipping.

Fig. 9. Alligator cracking [13]

A rather frequent surface pavement repair processes are renovations of the asphalt pavements. The advantages of this approach include:
- the possibility to increase pavement strength without increasing its thickness,
- correcting the composition of the current mineral-asphalt mixture,
- removing so-called reflective cracks in a new abrasive layer applied on a damaged pavement,
- the possibility to repair pavement superstructure,
- the possibility to perform the work without shutting down the entire facility,
- limiting interference in the natural environment, involving decreasing the operating rate of existing material resources.

There are three main methods for recycling airfield pavements, i.e.: surface, hot and cold.

All of the aforementioned methods are aimed at improving the composition of existing pavements by supplementing them with new material of appropriate properties. The renovation is executed solely during a dry time of the year, and it is very important that there is not precipitation.

4. Labour and resources, and time scales necessary for HS repair-renovation work

The execution a repair or renovation of a runway, taxiing and apron pavement is usually divided into stages.

The first stage are preparation work, aimed at identifying the scope of necessary work and determining the labour and resources necessary for the execution, taking into account the imposed time and technical standards. A very important element is the proper distribution of labour and resources, so that they do not hinder rapid work performance – so-called dislocation of labour and resources necessary to perform the planned work.

The second stage is already earthworks, involving the necessary activities associated with, i.e., removing damaged surfaces, cleaning, preparation of appropriate masses, etc.

Whereas the third stage are surface work, involving correct repair of HS pavements and so-called finishing work, including quick evacuation of labour and resources used during repair-renovation works.

After a conducted analysis of the damage to HS Wielbark and in order to maintain the time scale during combat operations (4 hours acc. to STANAG 2929), it was concluded that two segment should be repaired simultaneously (see Fig. 6). Hence, the number of equipment and employees (specialists) necessary to execute the repair is sufficient, at a level shown in Tab. 2.

Tab. 2. List of equipment and labour quantities (Source: Own elaboration)

No.	Activity name	Equipment	Employees
1	Bituminous mass preparation	Boilers with bituminous mass 2 pcs	4 people
2	Milling and cleaning of the pavement	Milling machine 2 pcs	6 people
3	Bituminous mass application	Asphalt spreader 2 pcs	6 people
4	Rolling	Roller 2 pcs	2 people
5	Horizontal marking painting	Car for painting horizontal markings 1 pc	2 people
6	Cleaning the entire HS	Airfield cleaner 1 pc	1 person

Therefore, to repair the HS Wielbork runway pavement, it will be necessary to employ 21 workers (specialists).

Required equipment and material resources for (repairing) restoring operating fitness of HS Wielbark should be placed on both aprons, in approx. 20 x 20 m squares – see Fig. 10.

In order to determine the time scale of repair-renovation work it is necessary to calculate the quantities of individual repair-requiring segments, as per the relationship:

$$A = \sum_{i=1}^{n} A_i \,, \tag{1}$$

where:

A – total area of the runway-requiring repair,

i – number of consecutive pavement fragment to be repaired,

n – number of all identified pavement fragments to be repaired,

A_i – the area of the next damaged pavement fragment.

After taking into account all identified runway pavement damage, measuring them and calculation as per the relationship (1), it was stated that the total area of the first runway segment was 7.11 m^2, while the second was 7.48 m^2. Therefore, it can be assumed that they are similar in terms of the area, hence the validity of a rather uniform allocation of labour and resources for their removal.

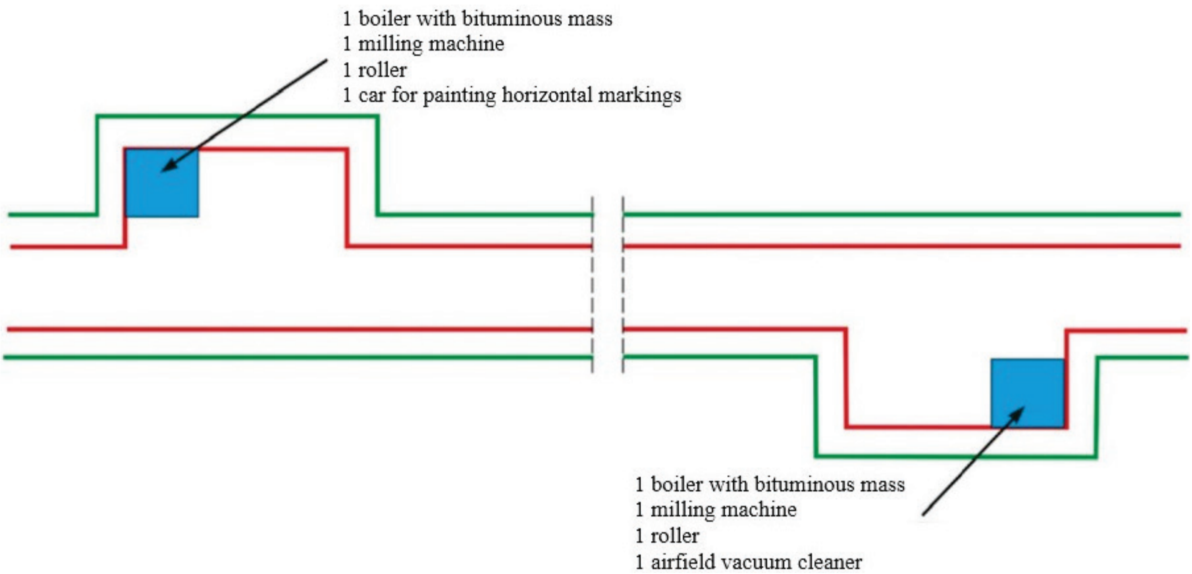

Fig. 10. Distribution diagram for the equipment necessary to repair HS Wielbark. Source: Own elaboration

Whereas for calculating the road airstrip repair time, it is required to adopt the following assumptions (based on standards or statistical data):

- milling and cleaning pavement residues: 0.17 m^2/min,
- bituminous mass melting time: 40 min,
- sweeper: 2.43 m^2/min,
- bituminous mass application: 0.159 m^2/min,
- horizontal marking painting: 50 m/min,
- rolling: 5 m^2/min,
- abrasive mass layer: 0.0765 t/m^2,
- total travel time between repaired areas: 10 min.

In addition, it was assumed that the repair process would be executed at a temperature of +10ºC and with no precipitation over the last few days, which would, among others, ensure the correct bituminous mass cooling process.

The calculations for the execution times of individual repair process activities showed that:

- the bituminous mass preparation time would be 40 min.,
- milling and cleaning of segment 1 (7.11 m^2) would be 52 min. in total, and segment 2 (7.48 m^2) 54 min.,
- the application of bituminous mass on segment 1 would take 55 min., while in segment 2, 57 min.,
- rolling: segment 1 with waiting for the completion of bituminous mass application is ca. 55 min., similarly to segment 2, also ca. 55 min.,
- the bonding of the abrasive layer for both segment is 40 min.,
- painting of the strip axis, threshold markings is ca. 55 min.,
- paint drying – 20 min.,
- cleaning the entire HS – 15.7 min.

Therefore, the total time of restoring combat fitness of the HS Wielbark runway will be 3 hours and 56 minutes. Hence, the time scales for the readiness of HS-s for operations are satisfied.

The ultimate activity is developing a repair schedule for the HS Wielbark in combat conditions. A suggestion for such a schedule is shown in Fig. 11.

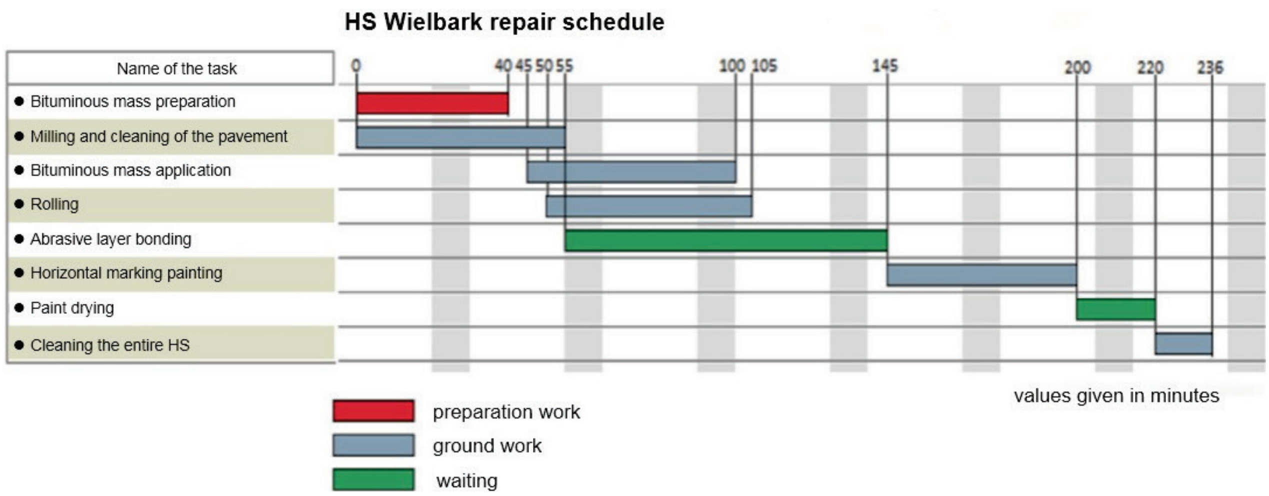

Fig. 11. HS Wielbark repair work execution schedule, source: own elaboration

5. Conclusions

Ultimately, it should be concluded that this type of approach towards Highway Strip repair planning processes is desired. A correct assessment of the existing damage performed well in advance, enables the selection of appropriate repair methods. Moreover, it will allow the determination of the labour and measures to repair the damaged runway fragments. Whereas, the determination of the optimal distribution of specialist equipment and labour will efficiently secure the execution of the repair process for individual HS segments.

Such an approach towards the organizational-technical planning of repair-renovation work involving Highway Strips will enable effective utilization of HSs during potential combat operations.

In the future, it is necessary to develop similar repair plans for the remaining Highway Strips, in order to enable their effective utilization in combat conditions. Developing plans for current repair and maintenance of Highway Strips is also important, since it would improve their technical condition significantly.

References

[1] Nita, P., *Construction and maintenance of airfield pavements*, WKiŁ, Warsaw 2008.
[2] Nita, P., *Report No. 9/24/2012, Bydgoszcz airport runway renovation technology*, Warsaw 2012.
[3] Olkowska. E., *The organization of the highway strip repair process in combat conditions*, B.Sc. Thesis, WSOSP, Dęblin 2018.
[4] Olkowska, E., Ungiert, D., *Logistics and defence in the light of new technologies. Rapid repair of airfield damage – technology and organization*, Military University of Technology, Warsaw 2017.
[5] Poświata, A., *Manual for the operational renovation of artificial airfield pavements*, Warsaw 1999.
[6] AFIT collective work, *Airfield guidelines. The construction of light-weight pavements on access roads to aircraft dispersal zones and other local roads*, AFIT, Warsaw 1964.
[7] Rajchel, J., Zabłocki, E., *Airport*, Air Force Academy, Dęblin 2008.
[8] Wesołowski, M., Blacha, K., *Assessing the load bearing capacity of airfield pavements with the ACN-PCN method*, Air Force Institute of Technology, pp. 7-8, Warsaw 2014.
[9] Wesołowski, M., *Highway strip design*, Dissertation, Military University of Technology, Warsaw 2000.

[10] *The Regulation of the Minister of Transport and Maritime Economy on technical-construction stipulations for civil airports*, Dz.U. of 26 October 1998.
[11] Attachment 14 ICAO Aerodromes Vol. 1, *Aerodrome design and operation*, International Civil Aviation Organization, ICAO 2009.
[12] Attachment to guidelines No. 2 of the President of the UCL (Civil Aviation Office) of 25 January 2016, *Methods for measurement assessment and runway pavement reporting*.
[13] Generalna Dyrekcja Dróg Publicznych, *General Directorate for Public Roads. Pavement assessment system*, Warsaw 2002.
[14] https://pl.wikipedia.org/wiki/Drogowy_odcinek_lotniskowy.
[15] https://www.fly4free.pl/uwaga-samolot-drogowe-odcinki-lotniskowe-w-polsce.
[16] https://www.wykop.pl/wpis/10013568/aircraftboners-lotnictwo-wojsko-militaria-mniej-wi/.
[17] www.pzlmielec.pl/download/gfx/pzlmielec/.../fod_szkolenie_dla_kontraktorow.pdf, access: 12.10.2017.
[18] http://lotniska.dlapilota.pl/wielbark-dol, access: 12.09.2017.
[19] http://www.inzynierbudownictwa.pl/technika,materialy_i_technologie,artykul,nawierzchnie_asfaltowe,4694, access: 16.10.2017.

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