# PLANNING OF THRESHOLD 35 RUNWAY END SAFETY AREA(RESA) AT RAHADI OESMAN KETAPANG AIRPORT, WEST KALIMANTAN PROVINCE

Widya Chairunnisa[1*] , Siti Fatimah[2] , Linda Winiasri[3]

[1,2,3)]*Politeknik Penerbangan Surabaya, Jemur Andayani I/73 Wonocolo Surabaya, Jawa Timur, Indonesia, 60236*
[*]*Corresponding Autthor Email:* widyachairunnisa14@poltekbangsby.ac.id

**ABSTRACT**
Rahadi Oesman Airport is one of the airports in West Kalimantan, which is managed by the Directorate General of Civil Aviation. The airport with runway dimensions of 1400 meters x 30 meters and has a flexible pavement type has not been equipped with RESA safety instruments at the end of the runway threshold 35. In order to prevent the risk of damage to aircraft experiencing overrunning and overshooting and to meet safety recommendations and operational standards, RESA planning was carried out at threshold 35 of Rahadi Oesman Airport. This planning is based on aviation safety and security standards contained in PR 21 of 2023 and Annex 14. Therefore, the planning will pay attention to the feasibility assessment including the dimensions, slope, and surface of the RESA. These factors will be used to obtain the results of excavation and embankment calculations with the help of PCLP, AutoCAD, and Microsoft Excel applications. RESA at threshold 35 of Rahadi Oesman Airport will be planned with dimensions of 90 meters x 60 meters and a transverse slope percentage of 1.3% and a longitudinal slope percentage of 0.6%. In this planning, the calculation of excavation volume is 1544.188 m3 and the volume of embankment is 38.446 m3 and requires a cost of Rp. 917,200,000.00 (Nine Hundred Seventeen Million Two Hundred Thousand Rupiah).

***Keywords:*** *Runway End Safety Area, PCLP, Cut and Fill, Soil Volume, Rahadi Oesman Airport.*

## 1. INTRODUCTION

Air transportation is one of the modes used to run the wheels of the economy, open access to remote or inland areas, strengthen the unity and unity of the nation and unite regions with each other. The need for this mode of transportation is increasing along with the increasing need for transportation services for the mobility of people and goods both domestically and abroad. Air transportation also plays an important role as a driver of regional growth and development of several regions. The important role of air transportation modes makes the Indonesia government continue to strive to improve the quality and service of aviation. Therefore, as an aviation service provider, the airport service unit has full responsibility for flight operations and safety.

Airport safety can be achieved by providing airport facilities and maintaining the airport environment that ensures the safety of aircraft operations (KP 39 of 2015). Yousefi et al. (2020) said that the idea of reducing the accident rate to 0% is impossible but preventive efforts to improve transportation safety such as identifying obstacles, checking location constraints, and ensuring that runway conditions and operational facilities are in optimal condition are mandatory requirements of aviation organizations.

Airside facilities are a vital area that is at the core of flight operations. According to Saputra (2017), the location of aircraft accidents often occurs in the runway area both when the plane is about to *take off* and when landing. KNKT noted that from 2015 to October 2022, the most frequent type of air transportation accident was *a runway excursion*.

Saputra (2017) in his journal stated that *runway excursion* is a condition when the aircraft stops in a position outside the runway, either on the right or left of the runway (*veer off*) or at the end of the runway (*overrun*). Meanwhile,ICAO defines RE as a state when an aircraft slips or leaves the runway during takeoff or landing, either intentionally by the pilot to avoid objects or objects on the runway or accidentally which can result in loss of life or damage to the aircraft (ICAO, 2008).

According to *the International Air Transport Association Safety Report*, RE accounted for 22% of the total aviation accidents during the period 2010-2014 (Yousefi et al., 2020). One of the efforts to prevent accidents in the form of aircraft derailment is to equip instruments or facilities for flight safety and security. *Civil Aviation Organisationation* requires each *runway* to have a *Runway Safety Area* (RSA) outside the runway surface as a zone for aircraft deceleration and stopping due to *overrun* (Yang et al., 2018). This statement is in line with the provisions of Presidential Decree 326 of 2019 concerning Technical and Operational Standards of Civil Aviation Safety Regulations, which states that *a Runway End Safety Area (RESA)* must be available at each end of the *runway strip*.

Based on Presidential Decree number 39 of 2015, *RESA* is a symmetrical area around the extension of the *runway centerline* and adjacent to the end of the runway strip, which is intended to reduce the risk of damage to aircraft due to undershooting or overrunning and allow aircraft that experience overrunning to reduce the speed and aircraft that experience undershooting can continue its approach or landing. The provision of RESA is important because in addition to the technical function to reduce the risk of aviation accidents, RESA must be provided at each airport to meet the safety and security standards that have been set by national and international aviation organizations.

One example of an airport that does not have the completeness of RESA instruments as a safety and security facility is Rahadi Oesman Airport located in Ketapang Regency, West Kalimantan. As a Class II Airport Operating Unit under the auspices of the Directorate General of Civil Aviation of the Ministry of Transportation, this airport has the second busiest operating hours in West Kalimantan after Supadio Airport. As a result of the condition of land transportation facilities in West Kalimantan that are not qualified, people tend to choose air transportation options as the main mode. In addition, the air route was chosen by the community because it has a more effective travel time. During peak hours, on average, this airport has 8-10 *movement flights* every day.

The dense operational hours of this airport cause an increasing risk of flight accidents that may occur. In addition, it was recorded that in 2017 there was an incident where an aircraft slipped out of the runway at Rahadi Oesman Airport, causing damage to aircraft wheels. Rahadi Oesman Airport already has a *safety plan* document regarding the non-fulfillment of RESA Runways 17 and 35, but it is not equipped with *risk assessment* and *risk mitigation* because it is considered not *hazardous.* On the other hand, there is the growth of residential areas around the *threshold,* increased aircraft movement traffic, and the *existence of hotel building obstacles* at the end of *threshold* 35 so that the runway extension that has been carried out cannot be used. Therefore, RESA planning at *threshold* 35 is important to be implemented to improve flight operational safety.

The provision of RESA instruments requires systematic planning with attention to operational feasibility assessments. Criteria that need to be considered include length and width (*dimension*), *longitudinal slope (longitudinal slope*), *transverse slope (transverse slope*), and *surface type (surface type*). These criteria are considered by referring to the technical requirements contained in the Decree of the Director General of Civil Aviation Number PR 21 of 2023 concerning Technical and Operational Standards of Civil Aviation Safety Regulations Part 139 (*Manual Of Standard CASR Part 139*) Volume 1 of the Land Aerodrome, Decree of the Director General of Civil Aviation Number KP 14 of 2021 concerning Technical Specifications for Airport Side Facility Work, *Annex* 14, and ICAO (*International Civil Aviation Organization*)).

Considering the importance of RESA procurement in flight operations to meet safety standards, the authors conducted research on runway end safety area planning at threshold 35 rahadi oesman airport ketapang. Runway End Safety Area planning will include the work of depicting existing and planned ground surface elevations, calculating the volume of excavation and landfill and calculating the required cost budget plan.

## 2. THEORETICAL FOUNDATION

### 2.1 Airport

Airport is defined as an area on land and/or water with certain boundaries used as a place for aircraft to land and take off, up and down passengers, loading and unloading goods, and a place for intra and intermodal transportation movements, which is equipped with aviation safety and security facilities.

### 2.2 Runway End Safety Area

In order to avoid damage to aircraft exiting the runway (Overrun), the International Civil Aviation Organization requires that all runways provide a zone to inhibit speed and stop aircraft experiencing overrun.

RESA is provided to minimize damage to an aircraft that overruns and overshoots or exits the runway. The surface must be prepared in such a way as to drag or slow down the aircraft and avoid more severe damage (collapse of the landing gear). Both of these objectives must be met and so ICAO provides guidance on the specification of RESA surfaces.

A thickness of 15 cm is the maximum depth that an aircraft wheel can sink without collapsing. Therefore in Annex 14 it is recommended that at a depth of 15 cm from the surface, the soil quality for the RESA area is prepared to drag the aircraft (deceleration of the aircraft) and the underlying layer has a bearing strength of 15-20% CBR value to withstand the weight of the aircraft. This 15-20% CBR value is considered to prevent the front wheels from sinking beyond 15 cm. There are several other provisions that need to be considered in the procurement of RESA including:

#### 2.2.1 Objects in the Runway End Safety Area (RESA)

Any object or object located in the Runway End Safety Area (RESA) other than equipment or installations required for navigation that may endanger the aircraft is considered an obstruction and should be removed if possible. Note that equipment required for air navigation for aircraft safety that is placed in the RESA area must be perishable and installed as low as possible in designated areas to minimize hazards.

### 2.2.2 Runway End Safety Area (RESA) Clearing and Leveling

Runway End Safety Area (RESA) is an area free of obstacles and flat for aircraft in case of undershooting or overrunning. The Runway End Safety Area (RESA) surface does not need to be made like a quality runway strip but still pay attention to the strength requirements of the RESA.

### 2.2.3 Slope of Runway End Safety Area (RESA)

The Runway End Safety Area (RESA) slope requirement is that the longitudinal slope of the RESA does not exceed a downhill slope of 5 percent while the transverse slope of the RESA, either downhill or uphill, is no more than 5 percent.

### 2.2.4 Sustaining the Runway End Safety Area (RESA)

In the case of RESAs where there are obstacles in the form of roads, railroads, other constructed or natural features, consideration should be given to the presence of these obstacles. If the Runway end safety area (RESA) provision cannot be implemented due to layout, consideration may be given to reducing some of the declare distance for the runway to allow the RESA to be provided (International Civil Aviation Organization, 2022).

### 2.3 Cut and Fill Work

Excavation and embankment is a process of earthwork where a number of soil materials are taken from one place and then stockpiled in another place. After the excavation and embankment work process, soil volume calculations are carried out to calculate the required planning costs. Measurement of soil volume can be done by two methods, namely manual calculation method and software or application assistance method.

### 2.4 Soil Volume Calculation Using PCLP application

PCLP (Plan, Cross Section, and Longitudinal Profile Program) is a software system used to convert data from Microsoft Excel into an autocad script. This software functions to simplify the work of calculating soil volume. In this research, the PCLP application is used as a volume calculation method because it is considered more efficient with higher accuracy compared to volume calculations using manual methods.

## 3. METHOD

This research uses descriptive analysis method in its data and information collection procedures. This method serves to describe and provide an overview of the object under study through data that is processed and analyzed to then draw conclusions. Data collection is carried out in three ways, namely direct observation to the field, collecting supporting data from available sources, and conducting literature studies to obtain data that strengthen the research.

Rahadi Oesman Airport already has land for RESA facilities as a result of local government acquisition at the end of the threshold 35 area but still does not meet the operational feasibility standards regulated by PR 21 Year 2023, Annex 14¸ and ICAO. There are several aspects that need to be considered in the procurement of RESA such as the required dimensions, uneven surface elevation conditions, slopes that do not meet the standards, and the presence of obstacles in the planning area. The research flow is presented in the following flow chart:

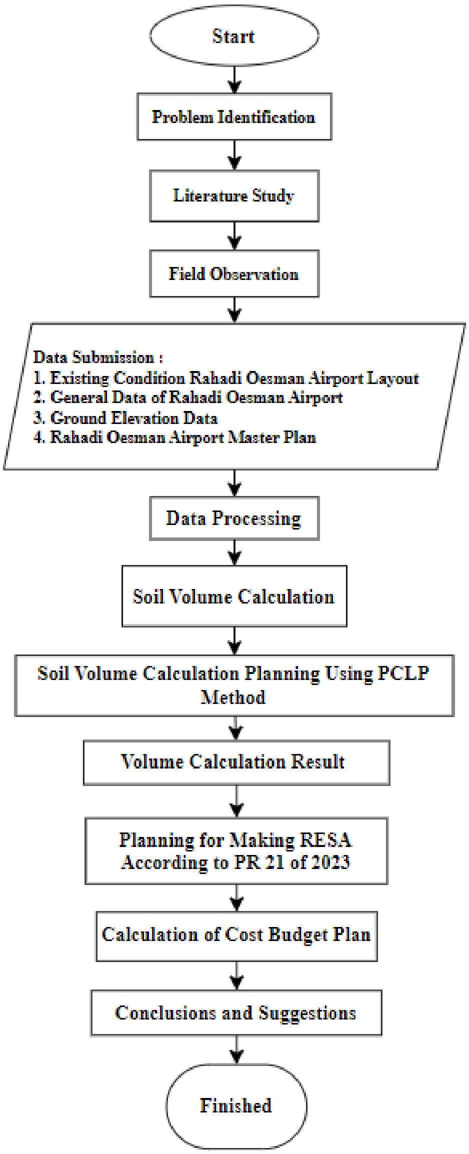



**Figure 1. Plan Flow Chart**

## 4. RESULTS AND DISCUSSION

### 4.1 Airport Reference Code Analysis

Airport reference codes are used to link various specifications about airport characteristics to determine a set of airport facilities that are suitable for aircraft operating at the airport. The airport reference code structure consists of two elements. Element 1 is a numeric code that indicates the runway length classification used by the most critical aircraft and element 2 is a letter code that indicates the classification based on the wingspan of the aircraft. Rahadi Oesman Airport itself has an active runway length of 1400 x 30 meters and is included in the non-precision instrument runway classification, the most critical aircraft operating are ATR 72-600 aircraft.

**Table 1. Aerodrome Reference Code**

| Code element 1 | | Code element 2 | |
|---|---|---|---|
| Code number (1) | Aeroplane reference field length (2) | Code letter (3) | Wing span (4) |
| 1 | Less than 800 m | A | Up to but not including 15 m |
| 2 | 800 m up to but not including 1 200 m | B | 15 m up to but not including 24 m |
| 3 | 1 200 m up to but not including 1 800 m | C | 24 m up to but not including 36 m |
| 4 | 1 800 m and over | D | 36 m up to but not including 52 m |
| | | E | 52 m up to but not including 65 m |
| | | F | 65 m up to but not including 80 m |

a. Distance between the outside edges of the main gear wheels.

Element 1 of the Airport Reference code is a numeric code that indicates the length of the runway used by aircraft. The ARFL (Aeroplane Reference Field Length) of the ATR 72-600 aircraft is 1290 meters, so the ARFL size is included in the code number 3 category where the ARFL category range is ≥1200 meters and <1800 meters.

Element 2 of the Airport Reference code is a letter code that indicates the aircraft wingspan category. Based on aircraft characteristics data, the ATR 72-600 aircraft has a wingspan of 27.05 meters so it is included in code letter C.

With the most critical aircraft type ATR 72-600 and based on the analysis of these two elements, it can be concluded that the reference code of Rahadi Oesman Airport, Ketapang is 3C.

### 4.2 Dimensional Analysis of RESA

The dimensional requirements of RESA based on PR 21 Year 2023 are as follows:

1. RESA Length
   The dimensions of the RESA (Runway End Safety Area) must extend from the end of the Runway Strip to a minimum of 90 m for:
   a. Code number 1 or 2 for instrument runway; and
   b. **Code number 3 or 4**.
2. RESA Width
   The width of the RESA (Runway End Safety Area) must be at least twice the width of the runway.
3. RESA Slope
   Longitudinal and transverse slopes do not exceed 5 percent. The planned slope for RESA threshold 35 Rahadi Oesman Airport will be adjusted to the slope of the exisiting area around the planning area which is 1.3% (transverse) and 0.6% (longitudinal).

### 4.3 RESA Site Plan Analysis

According to the FAA, there are two conditions for the placement of the resa area against the runway based on the availability of stopway facilities at an airport. The two conditions include:

1. The RESA area is located right at the end of the runway.

This provision applies to airports with conditions:
a. *Runway* code 3 atau 4 (90 m RESA)
*b.* *Runway* without *stopway*
c. *Runway* equipped with a clearway at its end.

2. Lokasi area is located 60 m after the end of the runway.

This provision applies to airports with conditions:
a. *Runway* code 2,3, or 4 (60 m RESA)
*b.* *Runway* equipped with a *stopway*
c. *Runway* equipped with a *clearway* at its end.

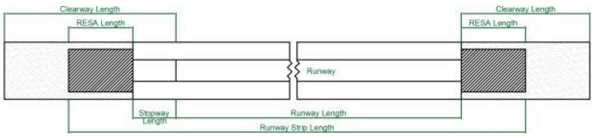



**Figure 2. Illustration of Clearway, Stopway, and RESA Positions**

Based on these provisions that are adjusted to the condition of the complete facilities owned by Rahadi Oesman Airport, the RESA location planning will be located at the end of the runway threshold 35.

### 4.4 Determination of RESA Plan Elevation

The elevation of the RESA plan is adjusted to the longitudinal and transverse slopes that have been analyzed previously.

1. Long Section

The RESA area with a length of 90 meters is divided into 19 elevation points with each point 5 meters apart with a planned longitudinal slope of 0.6%. The percentage slope of the slope is the comparison between the difference in height (elevation) and the flat distance between two points expressed in percent.

$$\textbf{Slope} = \frac{\textit{Height Difference}}{\textit{Flat Distance}} \textbf{ x 100\%} \qquad (1)$$

So to find out the magnitude of the decrease in each elevation (height difference) of the plan, the following formula is used,

**Height Difference = Slope x Flat Distance** (2)

For example, the calculation of the difference in plan elevation in STA 1+650 and STA 1+655 is as follows:

Plan elevation difference = slope (%) x Distance (m)

= 0,6 % x 5 m

**= 0,03 m**

Based on these calculations, each elevation point of the RESA plan on the longitudinal section has a cumulative change of 0.03 m. The results of the calculation on the longitudinal section are used as the midpoint for the elevation of the plan on the RESA transverse section. The following table is a table of the calculation an elevation of the elongated cut plan.

Table 2. Elevation Data of Longitudinal Section Plan

| LONG SECTION | | | | |
|---|---|---|---|---|
| STA | Distance | Existing Elevation (m) | Plan Elevation (m) | Elevation Gap |
| 1+650 | 5 | 9,926 | 9,926 | 0 |
| 1+655 | 5 | 9,836 | 9,896 | 0,03 |
| 1+660 | 5 | 9,806 | 9,866 | 0,03 |
| 1+665 | 5 | 9,774 | 9,836 | 0,03 |
| 1+670 | 5 | 9,743 | 9,806 | 0,03 |
| 1+675 | 5 | 9,714 | 9,776 | 0,03 |
| 1+680 | 5 | 9,754 | 9,746 | 0,03 |
| 1+685 | 5 | 9,795 | 9,716 | 0,03 |
| 1+690 | 5 | 9,835 | 9,686 | 0,03 |
| 1+695 | 5 | 9,876 | 9,656 | 0,03 |
| 1+700 | 5 | 9,917 | 9,626 | 0,03 |
| 1+705 | 5 | 9,802 | 9,596 | 0,03 |
| 1+710 | 5 | 9,688 | 9,566 | 0,03 |
| 1+715 | 5 | 9,572 | 9,536 | 0,03 |
| 1+720 | 5 | 9,458 | 9,506 | 0,03 |
| 1+725 | 5 | 9,346 | 9,476 | 0,03 |
| 1+730 | 5 | 9,538 | 9,446 | 0,03 |
| 1+735 | 5 | 9,729 | 9,416 | 0,03 |
| 1+740 | 5 | 9,920 | 9,386 | 0,03 |

2. Cross Section

The width of the RESA dimension is 60 meters so that 13 elevation points are taken with a distance of 5 meters at each STA and the planned horizontal slope is 1.3%. The plan elevation of each point is obtained by using the same calculation to get the plan elevation on the longitudinal cut. Taking an example of calculation on STA 1+650 as follows:

Plan elevation difference = slope (%) x Distance (m)

= 1,3% x 5 m

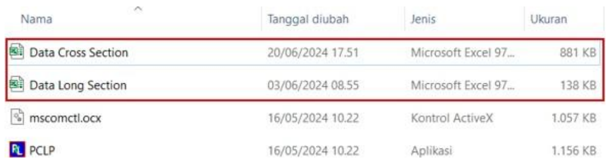
**= 0,065 m**

Based on this calculation, each elevation point on the transverse cut has a cumulative change of 0.065 meters. The 7th elevation point is the midpoint of the transverse cut so that the planned elevation value uses the result of the calculation of the planned elevation on the longitudinal cut (table 3).

### 4.5 Calculation of Excavation Volume and Soil Accumulation Using the PCLP Application

Volume calculations are done using the help of an application to obtain an accurate level of accuracy. The application used in this final project research is PCLP (*Plan, Cross Section, Longitudinal Profile Program*) *software*. Conceptually, the PCLP application makes it possible to convert data in *Microsoft excel* format into *Autocad Script* format so that it can be read by *the Autocad application.* The calculation of the volume of excavated and filled soil using *software* is carried out with the following steps:

1) Open the *Microsoft Excel* file that contains the program to enter the elevation data "Cross Section Data and Long Section Data”




Gambar 3. Program File Excel

2) Enter the existing soil elevation data into the Microsoft Excel program file

The existing ground elevation data on the cross section contained in the attachment in *the input* into a file named "Data Cross Section". Next, *input* the data one by one into the "OGL Data" sheet, enter the soil elevation data in *section* 'Y' and for the distance data per elevation in *section* 'X’.

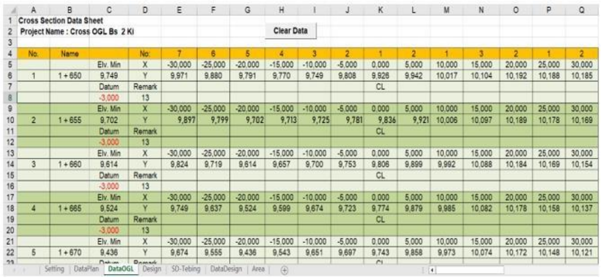
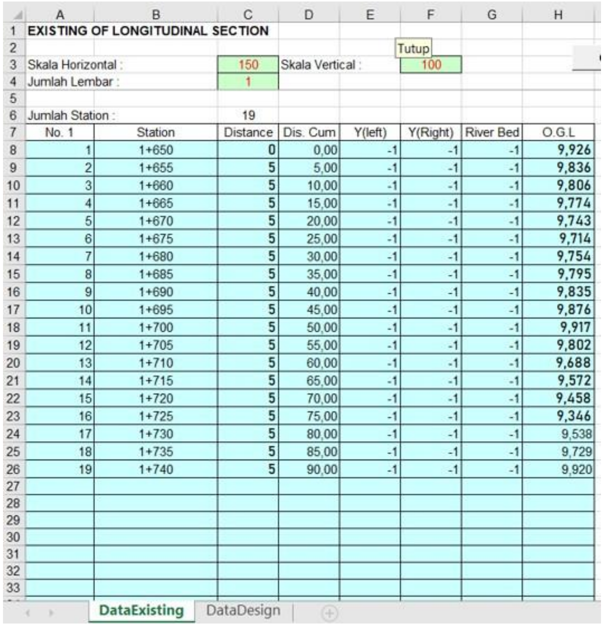


Figure 4. Data Cross Section Format

Meanwhile, for existing land data, long sections are entered in an excel program file called "Data Long Section". All elevation data in the RESA longitudinal cut are entered in the 'DataExisting' sheet, for the existing elevation value is entered into the 'O.G.L' column while the distance data between elevations is entered in the 'Distance' column. Input also the naming of elevation points per STA in the 'Station' column.



| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | EXISTING OF LONGITUDINAL SECTION | | | | | | | |
| 2 | | | | | | Tutup | | |
| 3 | Skala Horizontal : | | 150 | Skala Vertical : | | 100 | | |
| 4 | Jumlah Lembar : | | 1 | | | | | |
| 5 | | | | | | | | |
| 6 | Jumlah Station : | | 19 | | | | | |
| 7 | No. 1 | Station | Distance | Dis. Cum | Y(left) | Y(Right) | River Bed | O.G.L |
| 8 | 1 | 1+650 | 0 | 0,00 | -1 | -1 | -1 | 9,926 |
| 9 | 2 | 1+655 | 5 | 5,00 | -1 | -1 | -1 | 9,836 |
| 10 | 3 | 1+660 | 5 | 10,00 | -1 | -1 | -1 | 9,806 |
| 11 | 4 | 1+665 | 5 | 15,00 | -1 | -1 | -1 | 9,774 |
| 12 | 5 | 1+670 | 5 | 20,00 | -1 | -1 | -1 | 9,743 |
| 13 | 6 | 1+675 | 5 | 25,00 | -1 | -1 | -1 | 9,714 |
| 14 | 7 | 1+680 | 5 | 30,00 | -1 | -1 | -1 | 9,754 |
| 15 | 8 | 1+685 | 5 | 35,00 | -1 | -1 | -1 | 9,795 |
| 16 | 9 | 1+690 | 5 | 40,00 | -1 | -1 | -1 | 9,835 |
| 17 | 10 | 1+695 | 5 | 45,00 | -1 | -1 | -1 | 9,876 |
| 18 | 11 | 1+700 | 5 | 50,00 | -1 | -1 | -1 | 9,917 |
| 19 | 12 | 1+705 | 5 | 55,00 | -1 | -1 | -1 | 9,802 |
| 20 | 13 | 1+710 | 5 | 60,00 | -1 | -1 | -1 | 9,688 |
| 21 | 14 | 1+715 | 5 | 65,00 | -1 | -1 | -1 | 9,572 |
| 22 | 15 | 1+720 | 5 | 70,00 | -1 | -1 | -1 | 9,458 |
| 23 | 16 | 1+725 | 5 | 75,00 | -1 | -1 | -1 | 9,346 |
| 24 | 17 | 1+730 | 5 | 80,00 | -1 | -1 | -1 | 9,538 |
| 25 | 18 | 1+735 | 5 | 85,00 | -1 | -1 | -1 | 9,729 |
| 26 | 19 | 1+740 | 5 | 90,00 | -1 | -1 | -1 | 9,920 |

DataExisting DataDesign

Figure 5. Long section data format

After all the elevation data is inputted, the excel file is saved (ctrl+s) to continue processing the data in the PCLP *software*.

3) Open the PCLP Application

Open the PCLP application until the initial display appears as shown in figure 6.


Figure 6. PCLP initial view

4) Select the "Cross Section" or "Long profile" menu

The data that has been saved in Microsoft Excel and the plot settings will be automatically read by the PCLP application so that after the PCLP application is opened, select the Cross Section – Existing – OK menu to process the transverse cut data. And select the Long Profile-Existing-Carrier menu to process the longitudinal cut data.


Figure 7. PCLP Cross Section Display

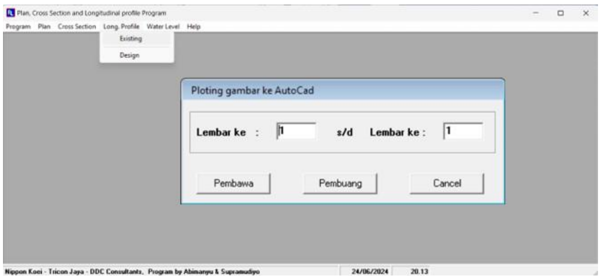



Figure 8. PCLP Long Profile Display

5) Save the Autocad Script Program file

The next step is to save the file, a display will appear to save the file in Autocad script format on a PC/Laptop, specify the location of the file storage, give it a name to distinguish between *cross section* and *long section* program files then click 'save'.

6) Open the Autocad app

Set up the autocad application on your PC/Laptop, open the application and select '*new drawing*'. Next, to read the output of the PCLP software, type the command 'SCR' – enter as shown in figure 9.


Figure 9. Command SCR

Next, a menu will appear to select the script file that has been processed in PCLP and saved previously. Select the script file to read the output, then click 'Open'. For example, the volume of excavation and soil heap will be calculated at STA 1+650.

7) Select the Script file

The output result of the PCLP on one of the transverse pieces, for example, STA 1+650 is taken as shown in figure 10.

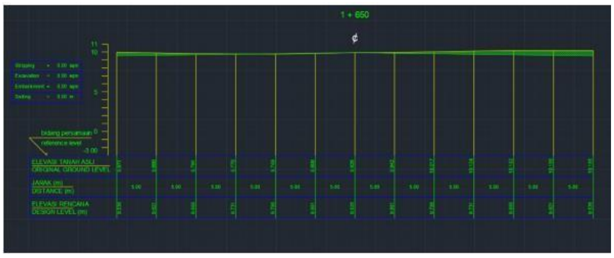



Figure 10. Transverse Cut Output

8) Volume calculation

Volume calculation is done by typing *the command 'Measuregeom'* - *V-O-Enter* and then hovering over the object to be calculated volume. Next, enter the number '*specify height*' or the distance between cross-sections in mm (5000 mm) – Enter, then the value of the volume of excavated soil or backfill at STA 1 + 650 (in mm) will appear.

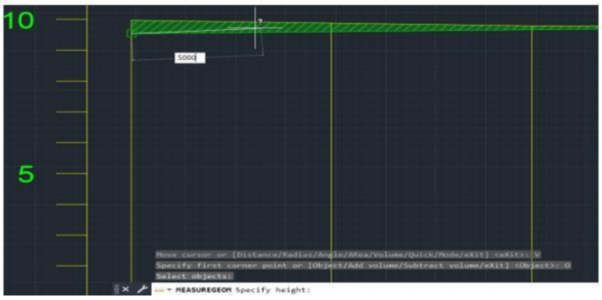



Figure 11. Volume calculation

9) Results of calculation of land volume

The total volume of *software* calculations obtained at each STA is listed in the following table:

Table 3. Data Results of Land Volume Calculation

| STA | Volume | | Total Volume ($m^3$) |
|---|---|---|---|
| | Cut ($m^3$) | Fill ($m^3$) | |
| a | b | c | d = (b - c) |
| 1+650 | 69,059 | 2,234 | 66,825 |
| 1+655 | 67,409 | 3,209 | 64,2 |
| 1+660 | 66,371 | 3,421 | 62,95 |
| 1+665 | 66,547 | 4,947 | 61,6 |
| 1+670 | 67,073 | 6,685 | 60,388 |
| 1+675 | 68,111 | 8,624 | 59,487 |
| 1+680 | 64,291 | 3,691 | 60,6 |
| 1+685 | 63,404 | 1,704 | 61,7 |
| 1+690 | 63,333 | 0,446 | 62,887 |
| 1+695 | 63,79 | 0,002 | 63,788 |
| 1+700 | 67,913 | 0 | 67,913 |
| 1+705 | 66,113 | 0 | 66,113 |
| 1+710 | 66,813 | 0 | 66,813 |
| 1+715 | 67,738 | 0 | 67,738 |
| 1+720 | 68,79 | 0,566 | 68,224 |
| 1+725 | 71,605 | 2,918 | 68,687 |
| 1+730 | 112,35 | 0 | 112,35 |
| 1+735 | 158,15 | 0 | 158,15 |
| 1+740 | 205,33 | 0 | 205,33 |
| TOTAL | 1544,188 | 38,446 | 1505,742 |

### 4.6 Runway End Safety Area (RESA) Planning

In the planning of making RESA or *Runway Safety Area*, there are several stages of work in the implementation in the field. Every stage of work starting from the planning stage to the evaluation stage needs to be carried out systematically and planned so that it is expected to produce maximum work results. Several stages of planning work for the creation of *a Runway End Safety Area* (RESA) include the following points.

a. Measurement work

In accordance with the discussion that has referred to the provisions of PR 21 of 2023, the size of the RESA plan required by Rahadi Oesman Airport with the reference code 3C is 90 meters x 60 meters with an longitudinal slope of 0.6% and a transverse slope of 1.3%. Elevation measurements are carried out before work to determine the contours of the ground surface.

b. Equipment mobilization and demobilization

The work of making RESA requires the help of a number of heavy equipment in the field implementation stage. The process of bringing in (mobilization) and moving equipment (demobilization) is carried out systematically so that the work can be started and finished according to the plan. Some of these heavy equipment include dump trucks, excavators, bulldozers, and motor graders.

c. Clearing work

Clearing is a stage of work in the form of cleaning the work area or ground surface from garbage, shrubs, plants or trees in the work area, as well as objects that should not be in the location.

d. Excavation and stockpile work

Excavation and landfill work is the core stage of the RESA manufacturing work. The purpose of the excavation and stockpile work is to regulate and form a slope in accordance with the provisions that have been regulated for the needs of RESA. In accordance with the volume calculation that has been carried out, the total volume of soil excavation that will be planned is 1544,188 $m^3$ and the total volume of soil heap that is planned is 38,446 $m^3$.

e. Compaction work

After obtaining the planned elevation, the next work is soil compaction work carried out to obtain the recommended density for the RESA area. Compaction in the entire RESA planning area is an area of 5400 $m^2$. The purpose of this compaction is to restore the strength of the soil after excavation.

### 4.7 Calculation of Cost Budget Plan (RAB)

The calculation of the Cost Budget Plan in the RESA planning work is carried out using the volume of work that has been processed previously. The preparation of this cost budget plan refers to the 2024 Ketapang

Regency HSPK. The following is a table of the results of the calculation of the Cost Budget Plan (RAB) *for the Runway End Safety Area* at *Threshold* 35 of Rahadi Oesman Ketapang Airport.

Tabel 4. Cost Budget Plan Table

| COST BUDGET PLAN | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Work | : RESA Planning at Threshold 35 | | | | | | | | | | |
| Location | : Rahadi Oesman Ketapang Airport | | | | | | | | | | |
| NO. | WORK ITEM | UNIT | VOLUME | CALCULATION DETAILS | | | | | | Unit Price | Amount price |
| | | | | Length | x | Width | x | High | Amount | | |
| a | b | c | d = h | e | | f | | g | h=(e x f x g) | i | g = ( i x d) |
| I | PREPARATION WORK | | | | | | | | | | |
| 1 | Directors quarter construction work | m2 | 36 | 9 | x | 4 | x | | 36 | Rp 1.069.399,24 | Rp 38.498.372,64 |
| 2 | Project signage work | Unit | 1 | | x | | x | | 1 | Rp 757.192,80 | Rp 757.192,80 |
| 3 | Mobilization and Demobilization | Ls | 1 | | x | | x | | 1 | Rp 30.000.000,00 | Rp 30.000.000,00 |
| 4 | Health dand Safety Equipment | Ls | 1 | | x | | x | | 1 | Rp 14.800.000,00 | Rp 14.800.000,00 |
| 5 | Measurement work | m2 | 5400 | 90 | x | 60 | x | | 5400 | Rp 5.150,20 | Rp 27.811.080,00 |
| | | | | | | | | | | Amount II | Rp 111.866.645,44 |
| II | EXCAVATION AND EMBANKMENT WORKS FOR THE CREATION OF RESA | | | | | | | | | | |
| 1 | Clearing Work | m2 | 8800 | 110 | x | 80 | x | | 8800 | Rp 24.139,06 | Rp 212.423.728,00 |
| 2 | Excavation Work | m3 | 1544,188 | | x | | x | | 1544,188 | Rp 273.919,22 | Rp 422.982.772,49 |
| 3 | Local Soil Embankment Work | m3 | 38,446 | | x | | x | | 38,446 | Rp 12.436,80 | Rp 478.145,21 |
| 4 | Compaction Work | m2 | 5400 | 90 | x | 60 | x | | 5400 | Rp 14.557,10 | Rp 78.608.340,00 |
| | | | | | | | | | | Amount II | Rp 714.492.985,71 |
| AMOUNT (I+II) | | | | | | | | | | | Rp 826.359.631,15 |
| PPN 11% | | | | | | | | | | | Rp 90.899.559,43 |
| TOTAL AMOUNT | | | | | | | | | | | Rp 917.259.190,57 |
| ROUNDDOWN | | | | | | | | | | | Rp 917.200.000,00 |
| SPELLED: *Nine Hundred Seventeen Million Two Hundred Thousand Rupiah* | | | | | | | | | | | |

This calculation is a calculation of the budget plan for the implementation of work in 2024. If the realization of work is carried out in the following year, a recalculation is needed by taking into account the inflation rate that occurred in that year.

## 5. CONCLUSIONS AND SUGGESTIONS

Based on the results of the discussion regarding the planning of *the Runway End Safety Area* (RESA) at the end of *runway threshold* 35 of Rahadi Oesman Ketapang Airport, the following conclusions were drawn:

1. The land elevation of the *Runway End Safety Area* (RESA) planning area at *threshold* 35 of Rahadi Oesman Airport has been described in accordance with *the existing* elevation and the planned elevation. Pictures of the situation are attached in appendix D.
2. Based on the results of the calculation of excavation and stockpile of *Runway End Safety Area* (RESA) planning through the PCLP *software* method, it was found that the excavation of the soil required for planning was 1,544,188 $m^3$ and the land pile was 38,4462 $m^3$.
3. The results of the calculation of the costs required, the planning of the Runway End Safety Area (RESA) threshold 35 at Rahadi Oesman Airport requires a cost of Rp. 917,200,000.00 analysis of the Budget Plan Cost (RAB) is based on the Standard Unit Price of Goods Needed by the Ketapang Regency Government in Fiscal Year 2024.

There are several suggestions that can be considered, among others:

1. Based on PR 21 of 2023 and Annex 14 which states the operational feasibility standards, each airport is required to have a security facility in the form of a Runway End Safety Area at each end of the threshold. Therefore, it is recommended that Rahadi Oesman Ketapang Airport immediately realize the Runway End Safety Area (RESA) at the 35th threshsold.
2. It is hoped that the next author can discuss the quality plan of soil strength with the CBR test on excavated or embanked soil for planning the Runway End Safety Area.

## REFERENCES


[1] Ariansyah, A., Yulianto, Y., & Permana, E. S. (2022). Pelaksanaan Pekerjaan Cut And FillPada Proyek Pembangunan Kawasan Pt. Plie Karawang Jawa Barat. *Jurnal Teknik*, *6*(2), 18–28.

[2] Ayuningtias, L. P. R. A. (2022). *Perencanaan Pembuatan Runway End Safety Area ( Resa ) Di Ujung Runway 14 Bandar Udara Sultan Muhammad Salahuddin Bima*. (Unpublished final project). Aviation Polytechnic of Surabaya. Surabaya, Indonesia.

[3] Azzahra, S. (2022). *Perencanaan Runway End Safety Area Di Runway 03 Bandar Udara Melalan Kutai Barat Perencanaan Runway End Safety Area Di Runway 03 Bandar Udara Melalan Kutai Barat*. (Unpublished final project). Aviation Polytechnic of Surabaya. Surabaya, Indonesia.

[4] DAS, B. M., & Sobhan, K. (2014). *Principles of Geotechnical Engineering* (H. Gowans (ed.); 8th ed.). Stamford, USA:Global Engineering.

[5] Undang-Undang Republik Indonesia Nomor 1 Tahun 2009 tentang Penerbangan, Pub. L. No. UU Nomor 1, 267 (2009).

[6] Peraturan Direktur Jenderal Perhubungan Udara Nomor KP 39 Tahun 2015 tentang Standar Teknis dan Operasi Peraturan Keselamatan Penerbangan Sipil- Bagian 139 (Manual Of Standard CASR-Part 139Volume 1 Bandar Udara (Aerodromes), 534 (2015).

[7] Keputusan Direktur Jenderal Perhubungan Udara Nomor KP 14 Tahun 2021 tentang Spesifikasi Teknis Pekerjaan Fasilitas Sisi Udara Bandar Udara, 436 (2021).

[8] Keputusan Direktur Jenderal Perhubungan Udara Nomor PR 21 Tahun 2023 Tentang Standar Teknis dan Operasional Peraturan Keselamatan Penerbangan Sipil Bagian 139 (Manual Of Standard CASR Part 139) Volume 1 Aerodrome Daratan, 451 (2023).



[8] Keputusan Direktur Jenderal Perhubungan Udara Nomor PR 21 Tahun 2023 Tentang Standar Teknis dan Operasional Peraturan Keselamatan Penerbangan Sipil Bagian 139 (Manual Of Standard CASR Part 139) Volume 1 Aerodrome Daratan, 451 (2023).



[9] International Civil Aviation Organization. (2020). *Doc 9157 Aerodrome Design Manual Part 1 - Runways* (Patent No. Fourth Edition). Quebec, Canada: Author. Diambil dari https://standart.aero/en/icao/book/doc-9157-p-1-aerodrome-design-manual-part-1-runways-en-cons

[10] International Civil Aviation Organization. (2022). *Annex 14 to the Convention on International Civil Aviation - Aerodomes - Volume I - Aerodrome Design and Operations*. Quebec, Canada: Author. Diambil dari https://store.icao.int/en/annex-14-aerodromes

[11] Majid, A. H. (2020). *Perhitungan Volume Galian Timbunan Dan Estimasi Biaya Universitas Jember Kampus Bondowoso Sisi Barat*. (Final Project, University of Jember, 2020). Taken from https://repository.unej.ac.id/handle/123456789/65736/browse?type=author&value=MAJID%2C+Abdul+Haris

[12] Prasetyo, A. B. (2022). *Perencanaan Pembuatan Runway End Safety Area di Ujung Runway 09 Bandar Udara Binaka*. (Unpublished final project). Aviation Polytechnic of Surabaya. Surabaya, Indonesia.

[13] Riyanto, F., Oktavi, M., & Marlianton. (2020). Estimasi Sumberdaya Batubara Terukur Menggunakan Metode Trapezoid Di PT. Tebo Prima Desa Kemantan Kelurahan Sungai Bengkal Kabupaten Tebo Provinsi Jambi. *Mine Magazine*, *1*(1), 1–5. https://ojs.umb-bungo.ac.id/index.php/MineMag/article/download/309/371

[14] Rosida, A., Kahar, S., & Awaluddin, M. (2013). Perbandingan Ketelitian Perhitungan Volume Galian Menggunakan Metode Cross Section Dan Aplikasi Lain (Studi Kasus: Bendungan Pandanduri Lotim). *Jurnal Geodesi Undip*, *2*(3), 1–9.

[15] Salam, A. K. (2020). Ilmu Tanah. In *Akademika Pressindo* (2nd ed.). Bandar Lampung, Indonesia: Global Madani Press.

[16] Santoso, D., Fatoni, K. I., Djunarsjah, E., & Setiyadi, J. (2015). Hitungan-Hitungan Volume Pengerukan. *Jurnal Hidropilar*, *1*(1), 45–56. https://doi.org/10.37875/hidropilar.v1i1.20

[17] Saputra, A. D. (2017). *Studi Analisis Penyebab Runway Excursion di Indonesia Berdasarkan Data Komite Nasional Keselamatan Transportasi (KNKT) Tahun 2007-2016*. *2016*, 93–105. https://doi.org/10.25104/wa.v43i2.305.93-104

[18] Universitas Islam An Nur Lampung. (2023). *Perhitungan Peta Kontur dan Kemiringan Lereng*. Lampung, Indonesia: Author. Taken from https://mapvisionindo.com/kemiringan-lereng/

[19] Yang, X., Yang, J., Zhang, Z., Ma, J., Sun, Y., & Liu, H. (2018). A review of civil aircraft arresting system for runway overruns. *Progress in Aerospace Sciences*, *102*(April), 99–121. https://doi.org/10.1016/j.paerosci.2018.07.006

[20] Yousefi, Y., Karballaeezadeh, N., Moazami, D., Zahed, A. S., Mohammadzadeh, D., & Mosavi, A. (2020). Improving Aviation Safety through Modeling Accident Risk Assessment of Runway. *IJERPH*, *17*(17), 1–37. https://doi.org/10.3390/ijerph17176085