Crib Retaining Wall

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Abstract: Crib retaining wall or crib log retaining wall is one of the oldest types retaining wall. They consist of cribs or cells made of timber, concrete, and plastic/fibers. The cribs or-interlock areas are filled with free-draining materials or earth back-fill, eliminating the hydrostatic pressure and enabling a free escape of water. In this paper we discuss about the history, scope and types of cribs and analysis of crib walls. It also contains uses and importance of the crib walls. Finally, advantages are discussed about crib walls. Crib walls can be described as a specialized form of gravity retaining structure made by using on-site fill material held within a constructed framework which may be of different materials. A crib retaining structure with live plants between crib layers is called vegetative crib wall. In this article, wooden logs and bamboos are considered as crib elements and live cuttings or rooted plants (vegetation) are laid between crib layers. A number of guidelines and manuals exist for construction of crib walls made of different materials based on practical experience, but there are no proper methods available for the analysis and design of vegetated log crib walls. This paper aims to fill this gap in designing or dimensioning vegetated crib walls. The paper describes the analysis, design and construction procedure of vegetated log crib wall in detail which may be useful for sustainable slope management practice.

KEYWORDS: Crib retaining wall, timber crib wall, Precast concrete retaining wall, wooden log crib retaining wall.

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1.INTRODUCTION

Concrete crib retaining wall are a type of gravity wall which comprises a system of interlocking header and stretcher blocks to retain granular fill that provides the necessary stabilizing mass to the wall. Crib wall are commonly used for residential purposes such as stabilizing building platforms and driveway access. They are very adaptable and can be straight, curved, or angled and incorporate landscape features if required. Heights typically vary from 2 meters to 12 meters. Crib walls are able to sustain differential settlement. They have been proven over many decades of use in New Zealand.

SCOPE: This specification covers the construction of proprietary timber crib and precast concrete crib retaining walls. The work to be executed under this specification consists of excavation for foundations, construction of reinforced concrete footing, precast concrete or treated timber crib wall, selected backfill in and behind crib wall, and subsurface drainage to the wall as shown on the drawings.

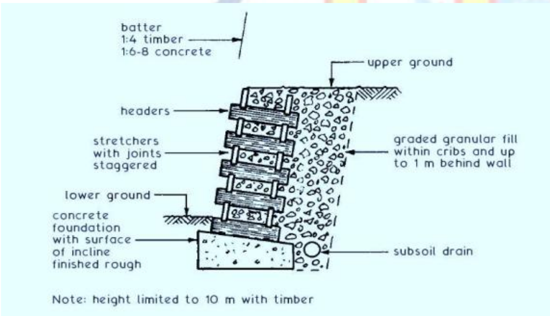


Fig: Crib Retaining wall

Requirements for quality control and testing, including maximum lot sizes and minimum test frequencies, are cited in specification part for quality requirements.

II. HISTORY OF CRIB RETAINING WALL

A crib retaining wall is a structure built up of longitudinal and transverse.

WOODEN LOG CRIB RETAINING WALL:

The wooden log crib retaining wall system was originally developed in place called "Kranj "in north Slovenia. The system of wall is popular under the name "Krainerwand" in German speaking countries. This type of wooden log wall has been used in the eastern Alps for many years. In early time, dead vegetation, vegetative parts or other materials such as boulders or stones were used betweencrib layers to prevent thefill material from coming out of the open spaces between crib elements during construction. A disadvantage of this method is its lack of durability since the dead wood materials rots fast. In such construction, when the wooden materials start decaying, the fill materials will start to come out from open spacesunder the influence of weathering agents (rainfall, sun, wind, snow etc.) and the whole structure will be collapsed. Therefore, Hassenteufel in 1934 used live willow branches between the crib layers instead of using boulders or stones. It is supposed that the growing plants gradually takeover the function of the rotting timber (Schiechtl and Bergmann 1994) through root reinforcement. To overcome the problem of decaying of dead plant materials placed between crib layers and to utilize reinforcing effects of plant roots, nowadays people have started to use live plants in the form of either rooted seedlings or vegetative cuttings of selective plants species. Depending upon the geographical locations, the species of plants used in vegetative crib wall varies widely. However, the commonly used plant species are willows, bamboos, Napier grass (Pennisetum purpureum), vetiver grass (Vetiver zinzaniode) etc. The crib retaining structure made of crib elements with live plants inside are called vegetative crib wall (or live crib wall), which is a kind of soil bioengineering wall. In this paper, wooden logs and bamboos are considered as crib element and live

Cuttings are used as filling support between cribs Layers.

Fig: Wooden log crib wall

TIMBER CRIB RETAINING WALLS:

Timber crib walls are use timber to form the cells of the crib. The cells are filled with free-draining stone materials or maintaining the mass of the wall. Water drainage can happen freely through the cribs the timber sections are interlocked to make the walls. They can also be planted with trees to create a natural appearance. These types of walls are ok up to a height of 5-6 meters and mostly used for landscape walls etc.

Fig. Timber crib retaining wall

PRECAST CRIB RETAINING WALL:

The system consists of a precast concrete header and stretcher units. They are erected to form precast crib retaining walls. Precast concrete cribs are the cheapest form of the earth-retaining systems and are used for landscaping structures, plant terraces, and other works with heights around 10-20 meters with proper professional design. They do not require any skilled labor to do the erection. Trees or shrubs are planted to give natural and excellent looks. Crib walls are erected for small curves and are considered very flexible material.

Fig. precast concrete crib retaining wall

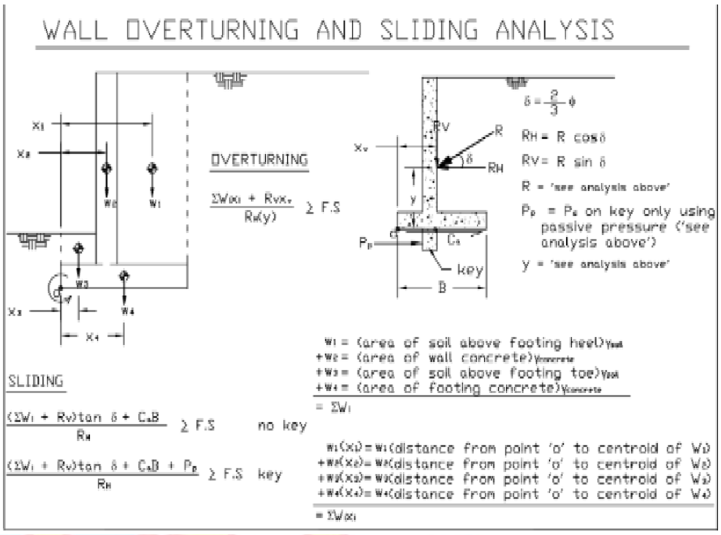
III. ANALYSIS OF CRIB RETAINING WALL

For the external stability, all forces (self-weight, earth pressure from the back fill another loads like water pressure, traffic loads, loads from structures etc.) acting on the wall are taken into consideration and crib wall is considered as a monolithic construction and analysis is done similar to gravity retaining walls. For internal stability of crib construction, soil theory is applied in the following safety checks should be performed for external and internal stabilities.

1. Sliding and overturning of wall
2. The overstress on foundation (Bearing capacity failure)
3. Sliding and overturning of crib elements
4. Overloading of crib elements and shearing of joints.

1. SLIDING AND OVERTURNING OF WALL:

Both are the failure modes of a crib retaining structure like wall, embankment, and anchor pile, tie pile, etc. Sliding mode of failure causes the wall to move and separate from the backfill, due to shearing failure at wall base. Overturning failure happens due to rotation of crib retaining wall about its toe, caused by the exceedance of moment because of the overturning moment value compared to the sum of resisting moments.



Check for overturning and sliding is basic laws of static. The factory of safety of sliding founded by dividing the sliding resistance value by sliding causing force value. Resistance force is a result of total downward force caused due to self-weight of wall at the base by friction. Sliding force is the horizontal earth pressure and exerted by backfill material.

Expression for computing the safety factor sliding is given below.

$$FS_{(overturning)} = \frac{\sum F_{R'}}{\sum F_d}$$

Here, the term $\sum F_{R'}$ is sum of horizontal forces resisting the movement and $\sum F_d$ is sum of driving forces.

The safety of factor for overturning is the ratio of total resistance moment and the total overturning occurs about toe of a retaining wall. Expression for computing factor of safety against overturning is given below.

$$FS_{(overturning)} = \frac{\sum M_R}{\sum M_0}$$

Here, the term $\sum M_R$ is total moment force to overturning the retaining wall about toe and $\sum M_0$ total moment force to resist overturning of wall about toe.

2.OVERSTRESS ON FOUNDATION BEARING CAPACITY FAILURE:

Distribution of pressure under this failure is assumed as the overstress on foundation or Bearing capacity failure the pressure exerted by the resultant of vertical forces at toe should be not exceed the allowable value of the bearing strength linear in nature.

Maximum pressure is given using the formula below.

$$P_{max} = \frac{R_v}{b}\left(1 + \frac{6e}{b}\right)$$

Factor of safety to prevent against the bearing failure will be given as below.

$$FOS = \frac{q_{na}}{P_{max}}$$

3. SLIDING AND OVERTURNING OF CRIB ELEMENTS:

In this safety check, the safety of single crib elements against the detachment from the crib system will be checked. Sometimes the earth side of crib will can have tensile forces in vertical directions, which might cause a lifting up or displacements of joints. In this case it is required to check the strength of joints. In case of inclined walls, the lifting walls, the lifting up of crib elements can be happened in two ways.

A) From vertical and horizontal forces
B) Lifting up from the forces parallel to wall inclination

A) FROM VERTICAL AND HORIZONTAL FORCES:

If $\bar{A}$, $\bar{B}$ = Self – Weight of cribs elements and soil trapped between crib layers in case of inclined crib wall, as

B. b*. cos α = N^*_B (z /2. tan α + b*. cos α) + G^*_3 (z/2. tan α + b*/2. cos α) + N^*_A. z/2. tan α

$\bar{B}$ = G_3/2 + N_B + z/2b*. tan α /cos α. (G_3 + N^*_A + N^*_B)

$\bar{A}$ = G_3/2 + N^*_A – z /2b*. tan α/cos α. (G_3 + N^*_A + N^*_B)

$\bar{A}$ + $\bar{B}$ = G_3 + N^*_A + N^*_B, for vertical walls, $\bar{A}$ = G_{3A} and $\bar{B}$ = G_{3B}

Where G_3 = Weight of crib elements in kN/m; N^*_B = Weight of fill material between crib layers (earth side) in KN/m; N^*_A = Weight of fill material between crib layers (outer side) in kN/m; G_2 = Weight of the fill material inside a crib cell in kN/m; G_1 = Frictional force from silo pressure KN/m; E_{va} = Vertical component of earth pressure from backfill in kN/m; A, B = Vertical component of forces on the joints (for inclined wall) in kN/m; A, B = Normal component of forces on the joints (for inclined wall) in kN/m. N_A, N_B = The weights of the fill material between crib stretcher elements in kN/m. z, Zn = Vertical and inclined heights of wall in m. h_E, h_{en} = Vertical and inclined heights from the base to the assumed point of action of the resultant in m. The vertical pressure at joints will be given by B =f (k. j. G_1, E_V, G_3, N_A, N_B, a, b*, z, h_E). Where k = a form factor which varies from 0.3 to 0.7, j = a reduction in mobilization of friction factor varies from 1 to 0.02*α° for 0° ≤ α ≤ 20°.

Tensile force at the earth side crib element due to horizontal component of earth pressure will be calculated as: B' = E_h / b*. cos a. (h_E – b*. sin a) Then the safety factor against the lifting up of crib elements at earth side will be given by F_{LC} = B / B'.

B) LIFTING UP FROM THE FORCES WALL PARALLEL TO INCLINATION:

In this case, the forces are resolved in parallel and normal direction to the wall inclination and the forces at the joint are calculated asNB= *kB*. j. G_{1N}+ $G_{3B,N}$ +E_{VN}. Then the safety against uplifting will be given by $F_{LC} = N_B / N'_B$. In the above equation $K_B \geq$ 0.5 and j ≤ 1 and for practical purpose, K_B * *j* can be assumed as 0.5. For each of these cases a global factor of safety of 1.5 will be required.

4.OVERLOADING OF CRIB ELEMENTS AND SHEARING OF JOINTS:

In crib wall, concentration of stresses will take place at the crossing points between stretcher and header elements. Therefore, care should be taken while selecting the size of crib elements so that the compressive and bending stresses at each element will not exceed the permissible limits. Based on the monolithic and silo theory assumptions, two safety checks are required in design practice. According to monolithic theory, the maximum compression at the outer side o crossing point is given by N_A = a'. N. (0.5 ± e / b'). Where a and b are the length and width of the crib walls, a' and b' are the effective length and width (fig).

a' = a + Width of header element.

b' = b + 2* Width of stretcher element.

Using the above equation, from the force diagram (fig), the force acting on the front and back joints (NA, N_B) can be calculated. Then the safety factor is given by $F_{CJA} = N_{ABreak} / N_{A, Available} \geq 1.5$.

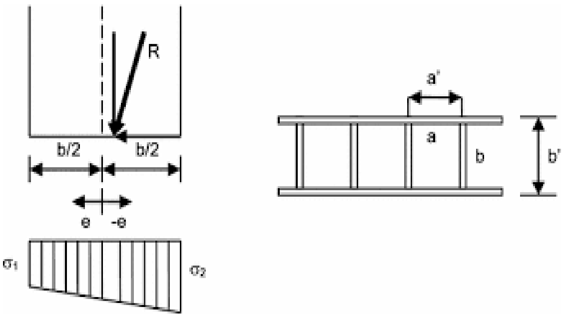


Fig. Illustration of the force acting on the wall base and distribution of pressure and crib cell dimension.

IMPORTANCE AND USE OF CRIB RETAINING WALL:

Crib retaining walls are usually meant to serve a single purpose, retaining soil that may erode, however, crib retaining walls have become more

Mainstream for other reasons. They are used to block off areas such as outer door living spaces and for landscaping.

The main reason to considering a crib retaining wall is to ensure don't have soil erosion from rain. Once you have an area with soil, you don't want to lose it. The main way you lose soil is through erosion. The crib retaining walls are meant to hold the soil, on a slope, without it eroding. Retaining walls can be used to help retain the areas around your home, keeping it safe from structural damages.

ADVANTAGES OF CRIB RETAINING WALL:

- Ease of construction.
- Do not require skilled labour.
- Easily and quickly erected
- Stability, Strength and Safety.
- Low cost.
- Require little or no maintenance.
- Aesthetics.
- Can be planted with flowers, shrubs or creepers.
- Adoptability.
- Incredibly flexible (can follows gentle curves, slopes, and undulating terrain).

CONCLUSION

- The performance of crib walls proves that this way of doing things is a good or helpful on money-based or other choice in slope management. As this way of doing things is more flexible, it can be easily combined with other geotechnical designing and building roads, bridges, buildings, etc. It can measure and also applied on in large-scale slope failures problems. When technically it able to be done, if there is a possibility to grow plants. This type of soil is using science to create specific living things ways of doing things can be adopted to produce equal or better money-based and related to surrounding conditions or the health of the Earth.
- The introduction of plants inside the fast-growing plant or wood crib wall will not only increases the life of such wall but also increases the firm and steady nature or lasting nature or strength of whole slope failures problems. When technically it able to be done, if there is a possibility to grow plants. This type of soil is using science to create specific living things ways of doing things can be adopted to produce equal or better money-based and related to surrounding conditions or the health of the Earth. The introduction of plants inside the fast-growing plant or wood crib wall will not only increases the life of such wall but also increases the firm and steady nature or lasting nature or strength of whole slope in long-run. Results show that the old way of doing things of making crib wall using the locally available material fast-growing plant or wood in making steady or making firm and strong slopes might be a doable or possible other choice to ordinary gabion walls. The after-performance ofthese walls showed or proved that this way of doing things could also be another choice for other geo-technical slope (making steady/making firm and strong) methods. What's more, this way of doing things allows for more long-term things that are good for the planet, such as air and water quality improvements and it can also be an able to last/helping the planet) solution to geotechnical problems. Things could also be another choice for other geo-technical slope (making steady/making firm and strong) methods. What's more, this way of doing things allows for more long-term things that are good for the planet, such as air and water quality improvements and it can also be an able to last/helping the planet) solution to geotechnical problems.

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