1 HISTORY

In the begining of the concrete roads, the original design of joints in pavement considerate only transversal joints in the most of the cases was only necesary transversal joints and the longitudinal joint where not considerate also the concept of corners load was thinking in a corner at the edge and the estadistic of the transit was maked with similar criteria, but when the width of the pavement was increase in the time, it was necesary to make longitudinal joints in the most of the cases; then overcame a new corner in the center of the pavement, this corner have a high percentage of traffic in the case of airports, urbans avenue, access to highway, access to interchanges, etc. then the load at the corner is important, when determining thickness.

2 INTRODUCTION

When you design joints, you never think about the thickness of the paviment, because it calculus is in function of the load, the imprint of the tire, the tensile stress of the concrete, the subgrade or the subbase resistence, the tranfer of load, etc. then, why if you considerate all this factors the pavement crack's at the corners slab in a short time like you see in many roads.

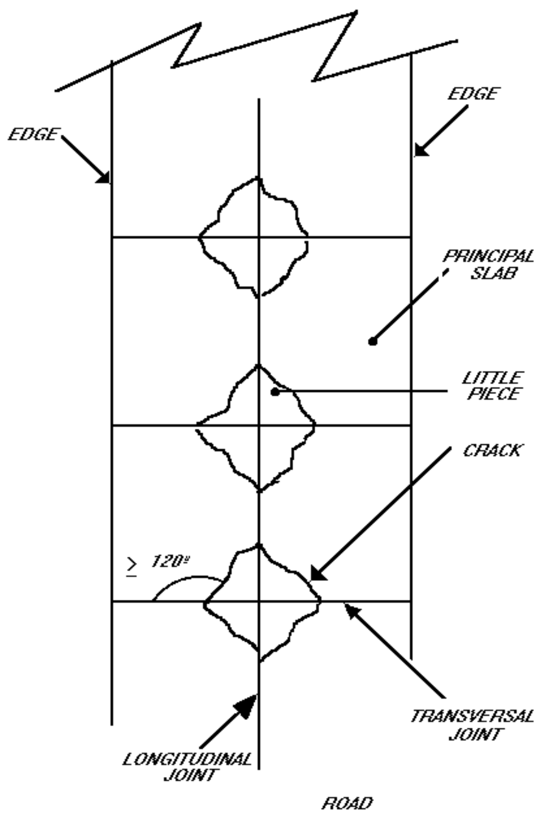

Figure 2

The crack of the pavement at the corners slab; became in the most of the cases, when a transversal joint cross a longitudinal joint (see Fig. 2); then we have in the slab two new pieces; first a principal slab and second a little piece; if you seal the crack and observe this rupture in the time; the principal slab don't cracks again, this is because the angle at the corner is 120º or more; what's make less tensile stress in the concrete; in the case of the little piece the condition of stresses change because the concrete works only to compression in this piece, then; if we make slabs with angles of 120º we have less tensile stress in the concrete than slabs with angles of 90º, how you will see in the mathematic demonstration.

This Paper will consist in a mathematic demonstration, that when the angle at the corner change ,the tensile stress in the slab will change too, in a very important percentage.

The original formules of calculus about the stresses in rigid pavement due corners load, only considerate angle of 90º at the corners slab.

A longitudinal joint cross a transversal joint in one point at the center of the pavement, then when you think about that say they are "two" joints at the point; but it's not true, because they are "four" joints at that point, then if we make hexagonals slab, the cross of the joints will be with angles of 120º, then we have "three" joints at that point, how you can see in the graphics of figure 1 is this new design of joints you have in anypoint between the edges of the paviment, angles of 120º and angles of 90º at the edge itself.

3 MATHEMATIC DEMONSTRATION

3.1 Stresses due to corners load

I will considerate two cases when we have only bending moment at the corner, first when the slab are square or rectangular and the corner slab have an angle of 90º; second, when the slab is hexagonal and the corners slab have an angle of 120º.

The tensile stress causes by bending moment in anycorner will be:

$$\sigma * W = P * \frac{B}{2} * tg\ \beta$$

$$W = \frac{B * H^2}{6}$$

$$\sigma = \frac{3P}{H^2} * tg\ \beta$$

W: section modulus φ: angle at the corner

Where, P, H, B, β, φ, is as shown in Figure 3.

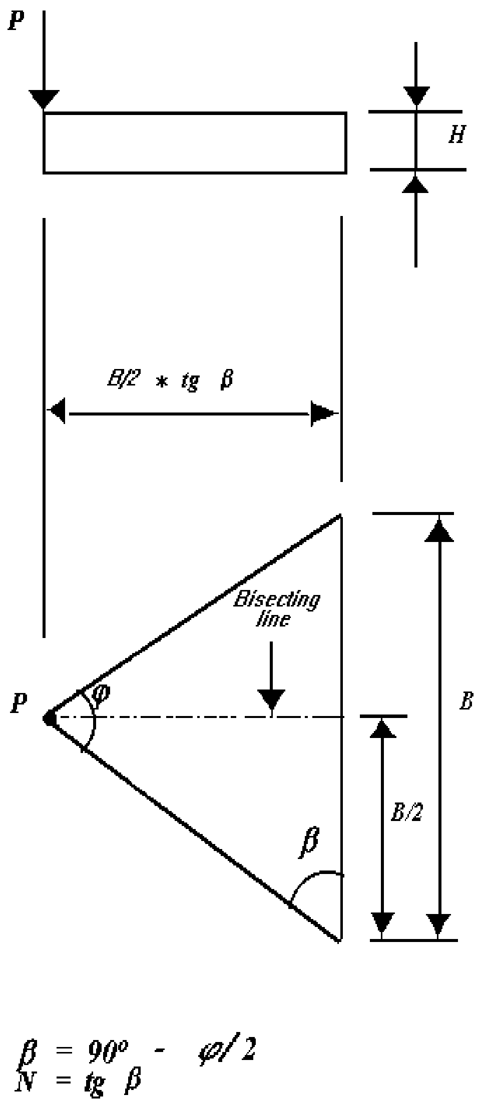

Figure 3

In the first case square or rectangular slab with angle (φ) of 90º at the corner, we have:

$\varphi = 90^{o} \quad \beta = 90^{o} - \varphi / 2 = 45^{o}$

Then, $tg\ \beta = tg\ 45^{o} = 1$

If we call N: tg β , the tensile stress will be:

$$\sigma = \frac{N 3 P}{H^2} = \frac{3 P}{H^2}$$

In the second case of hexagonals slab with angle (φ) of 120º at the corner, we have:

$\varphi = 120^{o} \quad \beta = 90^{o} - \varphi / 2 = 30^{o}$

$N = tg\ \beta = tg\ 30^{o} = 0{,}577$

Then, the tensile stress will be:

$$\sigma = \frac{N 3 P}{H^2} = \frac{0{,}577 * 3 P}{H^2}$$

3.2 Stresses due to corners load - Westergaard

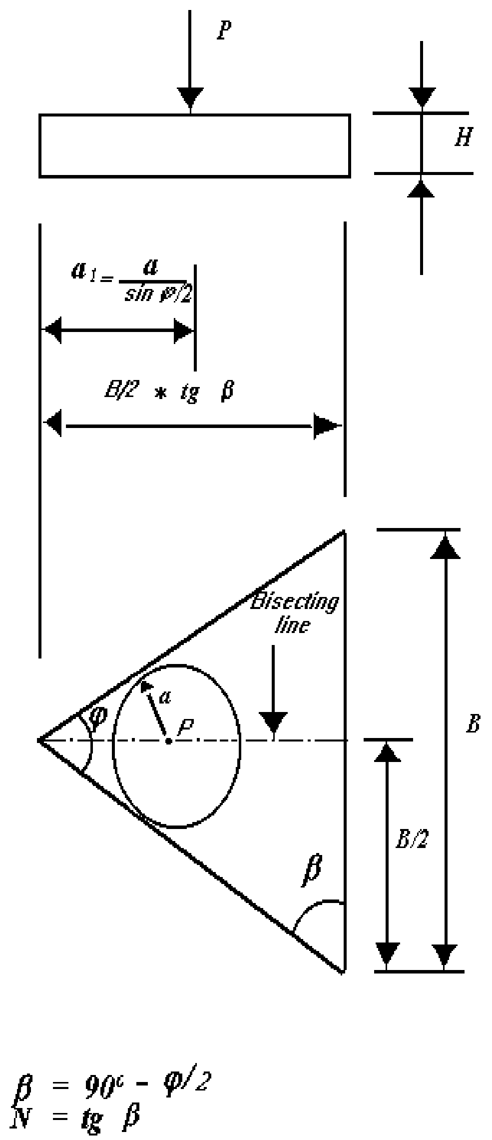

Figure 4

If we considerate the imprint of the tire and the support of the subgrade, like the original works of Westergaard for square or rectangular slab the tensile stress is:

$$\sigma = \frac{3P}{H^2} \left[1 - \left(\frac{a_1}{l} \right)^{0,6} \right]$$

Where:

σ : tensile stress
P: load
H: thickness

$$l = \left(\frac{E H^3}{12(1-\mu^2) k} \right)^{1/4}$$

l: radius of relative stiffness
a: radius, of the circular area equivalent to the contact of the tire with pavement
a_1: distance between the center of the tire and the vertex of the corner.
E: modulus of elasticity of the pavement
µ : poisson's ratio of the pavement
k: modulus of subgrade reaction.

3 . 3 Stresses due to corners load - This Paper

For this Paper the tensile stress for hexagonal slab is:

$$\sigma = \frac{N\ 3P}{H^2} \left[1 - \left(\frac{a_1}{l} \right)^{0,6} \right]$$

Where,

N = tg (90º - φ / 2)

φ: angle at the corner

$$a_1 = \frac{a}{\sin \varphi/2}$$

The term "a_1" change with the angle at the corner.

All the terms of this formules, don't change the original work of Westergaard if the angle (φ) is 90º, but when (φ) is different of 90º will changes the term "a_1" in function of the angle; and appears this new factor "N" in function of the angle (φ), too.

4 SLAB GEOMETRY

The hexgonals slab, bring us, corners with angles of 120º.
This New Design of Joints, as is shown in figure 1, bring us only one type of joint, because the concept slab lenght or slab width disappears; and don't exist longitudinals joints.

The basics concepts of the design are:

-Regulars hexagons inscripts in circles, radii= side
-Distance between parallels joints, not more 24 H
(H: thickness)
-Surface of the hexagon not more 30 m2.
-Never a joint will be parallel to the transit.
-The width of the pavement is = n a.
- (n: 3,6,9,....) (a:hexagons side)

5 CONCLUSION

1. The geometry of the slab is very important for determining tensile stresses due corners load.

2. If we have square or rectangular slabs, the original work of Dr. H. M. Westergaard, is valid 100 percent.

3. This Paper bring us the calculus of the tensile stress for slabs in wichs cases we have anyangle at the corners slab.

4. When, we have an asymmetrical intersection of roads and we design joints, never we do calculus of the tensile stress for slabs when they are not square, this Paper bring us it's calculus for different angles at the corners slab.

5. The factor "N" what's appears in this Paper will be generally, when the angle at the corner is φ:

N = tg (90º - φ / 2)

Then, when:

φ = 90º N = tg 45º = 1

φ = 120º N = tg 30º = 0,577

φ = 60º N = tg 60º = 1,732

6. The term "a_1", will change with the angle at the cormer φ, how see in the following formule:

$$a_1 = \frac{a}{\sin \varphi/2}$$