period during which such investment is actually tied up in the road—i.e., from the time the investment is made until the end of the 20-year period that is taken as the measure of the economic value of the road. In algebraic form this is done in the derivation of Formula I., which equation conveniently expresses the 20-year cost of a high-grade macadam road of 18-foot roadbed in dollars per mile. The interest that a municipality has to pay for money is seldom less than 2 per cent. per annum and a community of any standing would rarely have to pay more than 5 per cent. These limits have considerable effect upon the 20-year cost of the road, however, and in the case of the macadam construction (see Example 1) the difference in the economic value of the road for which the capital was raised by an issue of bonds carrying interest at 2 per cent. and an issue bearing interest at the rate of 5 per cent., for instance, would be a sum equivalent to nearly 120 per cent. of the original cost of construction, the two issues of bonds being taken at equally advantageous terms.

Derivation of Formula I, 20-year cost of Macadam Highway per mile.

Macadam Highway—18-ft. roadbed.

Note:—I=yearly rate of interest.

	Capital charges.	Interest charges.
Initial cost per mile	$12,000	
Interest on initial cost (20-yr.)		12,000 x 20 x I
Renewal charge per mile (end of 10 years)	6,000	
Interest on renewal charge (10-yr.)..		6,000 x 10 x I
Maintenance charges per mile (18 x $1,000)	18,000	
Interest on 18 increments of $1,000 each, equivalent to		1,000 x 179 x I

20-year cost per mile=12,000+240,000 x I+6,000+60,000 x I +18,000+179,000 x I.

20-yr. C=36,000+479,000 x I. .....Formula I.

Example 1.

Required:—20-year cost of high-grade macadam road (18-ft. roadbed) per mile, money at 2, 3, 4 and 5 per cent. per annum respectively.

At 2% =36,000+ 9,580= $45,580.
3% =36,000+14,370= 50,370.
4% =36,000+19,160= 55,160.
5% =36,000+23,950= 59,950.

Paved Roads.—The second class of highway, the paved roads, are particularly adapted to modern requirements of resistance to traffic wear and to-day find an economic field in rural service as well as in its former particular field in cities and localities of congested traffic. The modern vitrified brick highway is the class of road construction that forms the common link between roads for urban and rural service and which at the present time has a tendency to revolutionize established road building practices.

Roads may be classified according to the two general kinds of service, urban and rural. The paved roads for city service are of stone block (blocks of granite or of stone of similar characteristics), vitrified brick and of hard or soft wood block construction. For country service the vitrified brick paved road has proved not only suitable but truly economic. These paved roads, one and all, require suitable foundations for supporting the paving and the most adaptable construction, ordinarily also the cheapest and most durable, is the concrete foundation. Old macadam roadbeds or similar foundations may be used in particular instances, but in a general consideration of the economics of road building it may be assumed that the correct and usual foundation for paved streets is that of concrete of thickness suitable for the service to which the road is to be subject. (See Table II.) The cost of excavation, etc., may also be grouped with the cost of the foundation so that in straight-ahead road work a reliably accurate average cost of foundations, including excavation, etc., is known that varies directly with the thickness or depth of foundations. This cost of foundations is approximately the same whatever class of paving is to be employed and a reliable figure for this expense is $1,100 per mile of 18-foot roadbed for each inch in thickness of foundations. Based on such general values, the 20-year cost of the various types of paved roads, the measure of the economic value of the road, will be taken up independently.

Stone Block.—Formerly the stone block paved road, such as is commonly known as "Belgian block roads" in many localities, was universally used for city service where the traffic was heavy and such construction is still by far the most lasting of pavements, a properly constructed road of such class having an average life of some 40 years, during which time the average total yearly cost of maintenance per mile of 18-foot roadbed should not exceed $75 per mile. Without going into the details of construction, etc., the initial cost of such a road without foundations is about $22,500 per mile. The thickness of foundation should be about 8 in. or 9 in., preferably the latter. In fact, certain of the more eminent road building engineers claim that heavy trucking on stone-paved roads demands a minimum thickness of 9 in. for supporting concrete foundations. The derivation of Formula II. is dependent upon the foregoing and clearly indicates the various interest charges that such class of road construction must carry. Example 2, giving the average 20-year cost of stone-paved roads built with capital of varying value, shows that, on account of the heavy initial expense and low maintenance charges of this class of road, the same proportional difference does not exist in the 20-year cost with capital of different value as when the initial cost is not so great and the maintenance expenses are greater.

Derivation of Formula II, 20-year cost of Stone Paved Roads.

Stone Paved Highway—18-ft. roadbed.

Note:—I=yearly rate of interest.

	Capital charges.	Interest charges.
Initial cost per mile—		
No foundations	$22,500	
Concrete foundations .....1,100 x t		
Interest on initial costs (20-yr.)—		
No foundations		22,500 x 20 x I
Foundations		1,100 x t x 20 x I
Maintenance charges per mile (19 x $75)	1,425	
Interest on 19 increments of $75 each, equivalent to		75 x 190 x I

20-year cost per mile=22,500+450,000 x I+1,100 x t+ 22,000 x t x I+1,425+14,250 x I.

20-yr. C=23,925+1,100 x t+ (464,250+22,000 x t) I. Formula II.

Example 2.

Required:—20-year cost of stone block paved road (18-ft. roadbed) per mile, money at 2, 3, 4 and 5 per cent. per annum respectively—concrete foundation, 9″ thick.

At 2% =23,925+9,900+ (464,250+ 198,000) 0.02= $47,080.00
3% =23,925+9,900+ (464,250+ 198,000) 0.03= 53,702.50
4% =23,925+9,900+ (464,250+ 198,000) 0.04= 60,825.00
5% =23,925+9,900+ (464,250+ 198,000) 0.05= 66,947.50