ATTACHMENT 21 – Mn/DOT LRFD BRIDGE DESIGN MANUAL, CHAPTER 15 BRIDGE RATING, DATED JUNE 2007 DRAFT

(15 pages)

INTRODUCTION

Bridge ratings are administered and performed by the Bridge Rating Unit of the MnDOT Bridge Office. Bridge ratings may also be performed by other qualified engineers.

All bridges in Minnesota open to the public, with spans of 10 feet and more are rated. This includes all county and local bridges. However, bridges that carry pedestrians, recreational traffic, or railroad trains need not be rated. Culverts, with spans of 10 feet or more, are also rated, but by a different method. See the Culvert section of this chapter for more information.

Rating results are kept on file, and key information is entered in the Pontis database. From there annual reports are prepared and sent to the FHWA.

Bridge Ratings are calculated in accordance with the AASHTO Manual for Condition Evaluation of Bridges (MCE). This manual refers the user to the AASHTO Standard Specifications for Highway Bridges for much additional needed information.

An new rating method, LRFR, has been introduced. This method is described by the AASHTO Guide Manual for Condition Evaluation and Load Resistance Factor Rating (LRFR) of Highway Bridges.

Minnesota Statute Chapter 169 covers weights of vehicles. Other references related to bridges, ratings, inspections, vehicles, trucks, and weights include Minnesota Statutes, Chapters 163, 165, and 168, and Minnesota Rules, Chapters 8810 and 8820.

GLOSSARY

AASHTO: American Association of State Highway and Transportation Officials

ASD: Allowable Stress Design: The original AASHTO design method. The safety factors are applied by means of the material strength part of the structure capacity. Also called working stress design (WSD).

ASR: Allowable Stress Rating: The rating version of ASD

Dead Load: Those loads that are constant in magnitude, fixed in location, and remain in place permanently or for a long period of time.

FHWA: Federal Highway Works Administration

GVW: Gross Vehicle Weight: Total weight of the vehicle including the empty weight plus all variable loads such as freight, passengers, fuel, etc. (See also Minn Stat 169.01, Subd. 46.)

Impact: An additional live load expressed as a per cent increase of the vehicle live load. It represents the vertical forces due to vibrations and bouncing on rough bridge decks. AASHTO specifies the methods of calculation. It is always applied with the vehicle live load unless a specific reason is given otherwise.

Inventory Rating Level: As given by AASHTO, it is equivalent to the design level of stress. A bridge subjected to no more than this stress level can be expected to safely function for a life of 75 or more years.

Kip: k: A weight of 1000 pounds

Legal Load: The maximum GVW a truck may have without a permit. Minnesota Statute 169 defines this.

Legal Trucks: These are the model trucks used to determine load postings on bridges. The MCE defines them. Minnesota has adopted variations of them as given at the end of this chapter.
(Sometimes called Posting Trucks)

LFD: Load Factor Design: The AASHTO design method used for bridges from approximately 1975 to 1995. Independent load factors (or safety factors) are applied to the dead load, and to the live load.

LFR: Load Factor Rating: The rating version of LFD.

Live Loads: Transient loads that remain in place for a relatively short time. These are mainly vehicle loads: cars, busses, trucks, etc. Bridge rating is usually concerned with only the truck live loads. Other live loads are: construction equipment, pedestrian, wind, stream flow, and several others as given in the AASHTO design manual.

Load Rating: The determination of the safe live load carrying capacity of a new or an existing bridge using existing bridge plans supplemented by information gathered from a field inspection. The basic equation is given in MCE 6-1a.

Load Ratings may be subdivided into specific types depending on which live load is used in the denominator of rating equation. Some of these are:

Design Load Rating: The AASHTO HS truck and lane loads are used for the live load. The final rating is usually expressed relative to HS20. This is usually calculated at both the inventory and operating levels.

Legal Load Rating: (Sometimes called Posting Rating.) The live load is one or more of the "legal trucks". If the RF is less than 1.00 (or another specified amount), the bridge will be posted.

Annual Permit Load Rating: The live load model used represents a possible truck or class of trucks that may operate under an annual overweight permit.

Single Trip Permit Load Rating: The specific overweight permit truck model is used in the denominator of the rating equation.

LRFD: Load and Resistance Factor Design: AASHTO bridge design specification introduced in 1994. It has been gradually implemented over the approximate period of 1996 to 2005. Safety factors are applied to both the bridge capacity and to the loads.

LRFR: Load and Resistance Factor Rating: AASHTO bridge rating specification introduced in 2006. It has been implemented on only a limited basis at this time.

MCE: Manual for Condition Evaluation of Bridges, published by the American Association of State Highway and Transportation Officials (AASHTO). The second edition was published in 1994. Its use should also include all interims issued to date. (*alternate:* and interims were added in 1995,1998, 2000, 2001, and 2003..)

NBI: National Bridge Inventory: The aggregation of structure inventory and appraisal data collected to fulfill the requirements of the NBIS.

NBIS: National Bridge Inspection Standards: Federal regulations establishing requirements for inspection procedures, frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of bridge inventory records. The NBIS apply to all structures defined as bridges located on or over all public roads.

OFVCO: Office of Freight and Commercial Vehicle Operations: Issuing permits for overweight and overdimension vehicles is one of the functions of this office. They are in the Program Management Division of MnDOT. Their website: http://www.dot.state.mn.us/motorcarrier

Operating Rating Level: As given by AASHTO. The maximum permissible live load stress level to which a structure may be subjected. Allowing an excessive volume of vehicles to use the bridge at Operating Level may shorten the life of the bridge.

Permit Office: The unit of the Office of Freight and Commercial Vehicle Operations (OFCVO) that issues overweight / overdimension permits.

Pontis: The database that includes information on all bridges in Minnesota. It is maintained by the Bridges Office's Bridge Management Unit. Bridge ratings are part of that information. The "MnDOT Structure Inventory Report" contains a summary of the information.

Posted: The maximum loads allowed on a bridge are indicated by signs erected at each end of the bridge. Also known as Load Posted or Load Posting.

Rating Equation: Equation 6-1a of the MCE

RF: Rating Factor: The result of calculating the rating equation, MCE 6-1a. Generally RF $\geq$ 1.0 indicates that the member or bridge has sufficient capacity for the equated live load and is acceptable; and RF < 1.0 indicates overstress and requires further action. The RF may be converted to a weight by applying the equation, MCE 6-1b. An RF is always associated with a particular live load.

Rating: See Load Rating

Standard Permit Trucks: Model trucks used to determine the capacity of bridges for a broad group of overweight trucks. See diagrams at the end of this chapter.

TH: Trunk Highway: This consists of all highways under the jurisdiction of the State of Minnesota; Interstate, United States and Minnesota.

Type: Bridge type refers to a brief description of the bridge superstructure. The names and numerical codes for these are found in LRFD Design Manual, 2-87.

GENERAL

Bridges are rated at two different stress levels, Inventory level and Operating level. The Operating level is used for load posting and for evaluation of overweight permits.

In almost all cases only the primary load carrying members of the superstructure are rated. Decks or piers may have to be investigated in unusual circumstances such as severe deterioration. Unusually heavy permit loads may also require investigation of the deck and piers.

When rating a bridge, the final overall bridge rating should be the rating of the weakest point of the weakest member within the bridge. This is recorded on the cover sheet of the rating form.

The weakest link may change with different rating vehicles. This is because rating vehicles of different weights, axle spacings, and/or lengths have different effects on different members and spans. The identification of the controlling member, location, and limit state for each rated vehicle is given on page two (or three) of the rating forms.

Generally ratings are calculated for shear and for bending moment, and at the tenth points of each span and other critical points as needed. Other force effects that are sometimes checked are axial load and torsion.

MnDOT does not rate RR bridges. We do inspect them if they cross over a highway. Inspections are reported to the RR Company. If there are problems, they are brought to the attention of the RR and the RR is expected to act to correct them. The RR is to do any load rating. In our Pontis inventory we record only the design RR load.

MnDOT rates the bridges on the state highway system (Interstate, US, and Minnesota). Counties, cities, etc. each rate their own bridges. Where there are privately owned bridges on public roads, their owners are responsible for the ratings.

Ratings are performed by the Load Factor Method whenever possible. The Allowable Stress Rating and the Load and Resistance Factor Rating methods will sometimes be accepted alternatives.

Ratings may be done in LRFR. On the rating forms, report the ratings as "RF = 1.xx," and "RF = 1.yy," respectively for inventory and operating.

The use of computer programs is preferred for rating.

> Virtis is an AASHTOWare rating program introduced in 2001. It is capable of rating most bridge types.
>
> Other programs may be used for rating, provided they follow the MCE and other AASHTO specifications.

If one is doing a rating with Virtis, there is additional rating instructions available specific to Virtis. Inquire to the Bridge Rating Engineer.

Sources of information for a new rating or a rerating include the original plan, as built plan, the repair plan(s), existing rating, bridge Inventory data, and inspection reports.

Use the material strengths as given on the plan. If there is no plan and no other source is available, select from the values given in the MCE based on the year of construction.

In the past, most continuous steel beam spans have been designed as non-composite in the negative moment region. They should be rated the same way. Conversely, if the beam was designed for composite action in the negative moment region, rate it that way and with the longitudinal slab rebars included.

Bridge load raters have the option of using plastic capacity per section 10.50 of the standard specs

Temporary bridges are rated, the same as permanent bridges. Also, overweight truck permits are handled in the same manner as permanent bridges.

Use the serviceability requirements of section 10.57 of the standard specs when performing steel beam ratings.

Bearing stiffeners normally should not be allowed to control a rating.

Use a phi factor of 0.91 for prestressed concrete flexure in load factor rating.

Bridges entered in Virtis should be in the Girder System Definition whenever the bridge geometry will fit within the limitations of Virtis.

When using the Girder Line Superstructure Definition, rate an interior beam under a vehicle traffic lane.

LOADS

Dead loads and their distribution are calculated according to AASHTO.

Distribution of DL2: Railings, sidewalks, utilities and medians may be divided uniformly among all beams if they are located symmetrically on the deck cross section. Otherwise a different distribution method should be used which is logically sound.

Low slump concrete wearing courses and latex modified wearing courses are considered to be fully composite with the base slab. This might change for an individual bridge if an inspection showed that the bond between them is failing.

The topmost 0.5 inch of the wearing course or slab is not considered to be effective for composite action or section properties.

Composite section when deck is poured in two steps: This is usually 7 inches base, then a 2 inch low slump wearing course. DL1 Is defined as noncomposite dead load (stage 1) and DL2 as composite dead load (stage 2). DL1 includes the weight of the beam, diaphragms, and the initial slab pour . The remainder of the dead loads are then in DL2. MnDOT considers the effective composite deck supporting DL2 to be the initial slab pour. The effective composite deck supporting the live load (stage 3) is the full deck including the wearing course minus 0.5 inch. Most computer programs including BARS and Virtis will not accept these two different thicknesses of composite deck for stages 2 and 3. It is then necessary to use the final composite deck thickness as the one that also supports DL2.

Include a dead load for utilities of 2 psf of deck area in rural areas and 3 psf in cities and urban areas. Higher loads may be required if heavier utilities are shown on the plan or are known to exist.

Use a stool height of 1.5 inches for bridges designed in or after 1990 and 1 inch for before. Add as uniform dead load an additional weight to account for additional stool, residual camber, slope of the deck, superelevation, etc.

If the design includes an allowance for future dead loads, such as a wearing course, these should not be included in the ratings until such time as they are actually placed.

For steel bridges, account for the extra dead loads such as welds, splices, bolts, connection plates, etc. This generally ranges from 2 % to 5 % of the main member weight.

Design ratings are calculated and reported in terms of HS 20. Thus with the HS 20 truck as the live load in the denominator of the rating equation and if the resulting rating factor is 1.17, the rating would be recorded as HS 23.4

Use the AASHTO Spec for lateral distribution of live loads. Standard gage width (also called tread width) is 6 feet. For overweight permits treat gages of up to 7.0 feet as though they are 6 feet. For gage widths wider than this, an adjustment may be made to the axle weight so that an analysis can be completed as it is a conventional truck. Virtis version 5.5.0 will analyze non-standard gages. This paragraph also applies to axles of more than four tires.

RATING NEW BRIDGES

New bridges are to be rated anytime after the plan is completed and before the bridge is opened to traffic. The results are then turned in to the Bridge Management Unit for entering in Pontis.

For MnDOT bridges, the records remain inactive until Bridge Management is informed that the bridge has been opened to traffic.

If any changes are made to the bridge during construction that would affect the rating, these changes should be reported to the Bridge Ratings Unit (or the person who did the original rating), and also be recorded on the as built plans. This includes strand pattern changes for prestressed beams. The bridge rating is then recalculated.

RERATING EXISTING BRIDGES

A new bridge rating should be calculated whenever a change occurs that would affect the rating. The most commonly encountered types of changes are:

- A modification that changes the dead load on the bridge (For example: a deck overlay)
- Damage that alters the structural capacity of the bridge. (For example: being hit by an oversize load)
- Deterioration that alters the structural capacity of the bridge. (For example: rust, corrosion or rot.) (Scheduled inspections are usually the source of this information.)
- Settlement or movement of a pier or abutment.
- Repairs or remodeling.
- A change in the AASHTO Rating Specification
- An upgrading of the rating software.
- A change in laws regulating truck weights

The new rating should be completed, signed, dated, and filed, as outlined in the Forms and Documentation Section of this chapter. This most recent rating then supersedes any and all preceding ratings.

TIMBER BRIDGES

Timber plank decks should be rated. Use all the provisions of AASHTO Fig. 3.7.7 A with applicable footnotes. In other words, rate decks with individual axles of 16 k or 17 k or whatever the posting truck has.

Use wet condition for all rated timber members.

The repetitive use factor, C_r , can be used for plank decks, if they are covered by bituminous or perpendicular planks for load distribution. C_r may also be used for laminated decks if the panels do not show any separation or loss if lamination.

If timber members are in a deteriorated condition, their reduced capacity may be accounted for by reducing either the allowable stress or the section modulus.

When the original plan cannot be found, and the original design

OVERWEIGHT PERMITS

This section applies to state trunk highways only.

Maximum vehicle weights are defined in Minnesota Statutes. Under certain conditions, trucks may obtain permits to travel at greater weights.

Overweight and overdimension permits are issued by the Office of Freight and Commercial Vehicle Operations.

Among the tasks the OFCVO performs in the issuance of a permit are: communication with the trucker, recording of information, checking legal requirements for the truck, issuing the permit, collecting fees, determining the route for singe trip permits, and forwarding pertinent information to the bridge office for bridge checks. The computer program they use for processing permits is called Routebuilder NT.

The OFVCO issues annual permits for trucks weighing up to a maximum of 145,000 pounds. A holder of an annual permit may make an unlimited number of trips during the year of the permit. For routing they utilize the permit codes as recorded on our rating forms and maps. The trucker may make his own judgment of which weight class (A, B, or C) his trucks fits, or he may ask the permit office to determine the weight class. The permit office sometimes forwards these to the bridge office. These are commonly called "general checks."

The OFVCO also issues single trip permits. There is no maximum weight for single trip permits. All permit trucks have weight limits for single axles, and for certain axle groups.

Single trip permits are screened by the permit technicians at the permit office. Those permits with routes that cross bridges which are of questionable capacity are sent to the Bridge Rating Unit of the Bridge Office, for further evaluation. This is commonly called a "bridge check". The permit office screening techniques utilize the permit codes as recorded on our rating forms.

MnDOT Standard Permit Trucks.....figure zzzz. Rating factors and restriction codes are recorded on the rating forms for these trucks. The Bridge Management enters the codes into Pontis. They are also copied to permit bridge logs, and the annual permit routing maps. Class C is considered to be the composite of Std. C, P411, and P413 (sometimes called P4).

If the initial RF for a permit truck is less than 1,0, the truck may still be allowed to cross the bridge under a restriction. Overweight Permit Restrictions are shown in Figure 15-R-xx.

The standard gage of an axle is 6.0 feet, as given in the AASHTO Spec, Figure 3.7.7A. Permits of 6 to 6.5 feet gage are evaluated as though they were 6.0 ft. Axles wider than this and axles with more than 4 tires may be evaluated at a reduced equivalent weight then run in Virtis. (This reduced weight may be different for different type bridges depending on which live load distribution formula applies for the bridge.)

A truck traveling under an overweight permit may not cross a load posted bridge.

DESIGN OF PERMIT 4

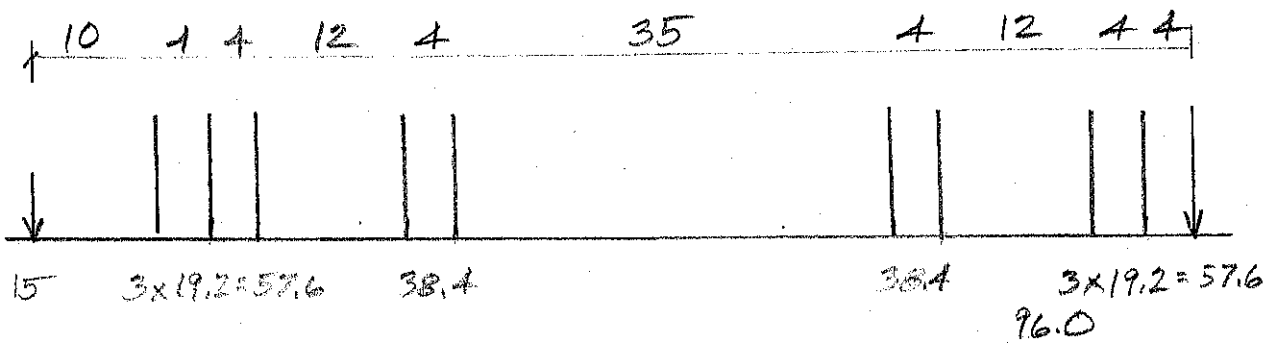
STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS

SHEET NO. ____
BRIDGE NO. ____
MADE BY ____
CHKG. BY ____
DATE ____

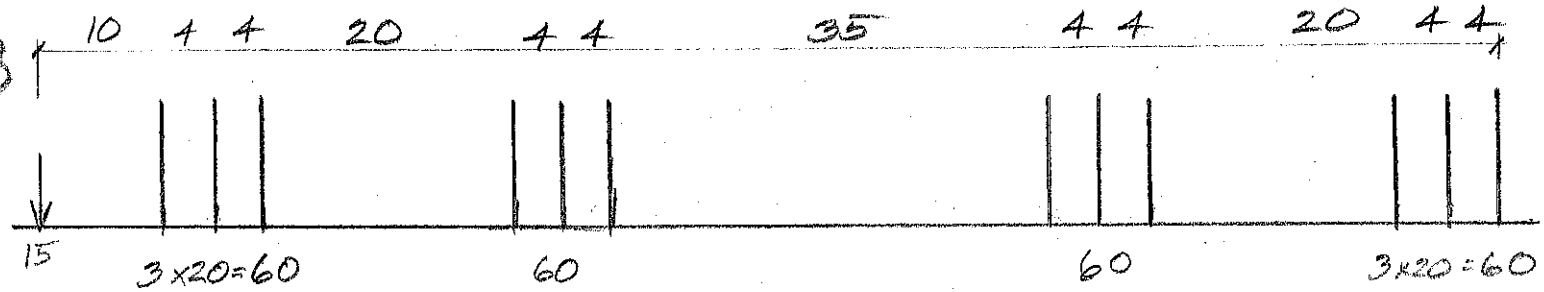
P411

2 x 5 Axle
207 k
93 ft
2.23 k/ft
= .191 ksf



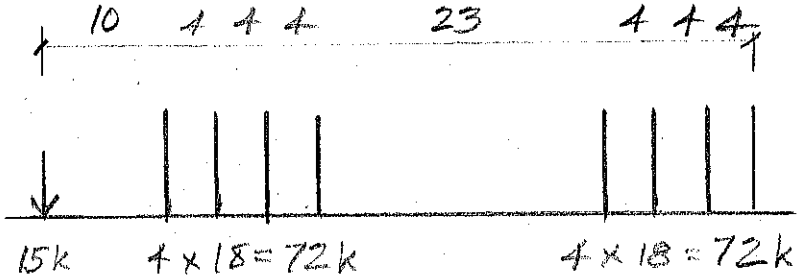
P413

2 x 6 Axle
255k
117 ft
2.18
.192 ksf



Std C

2 x 4 Axle, 159k
57'
2.79 k/ft
.237 ksf

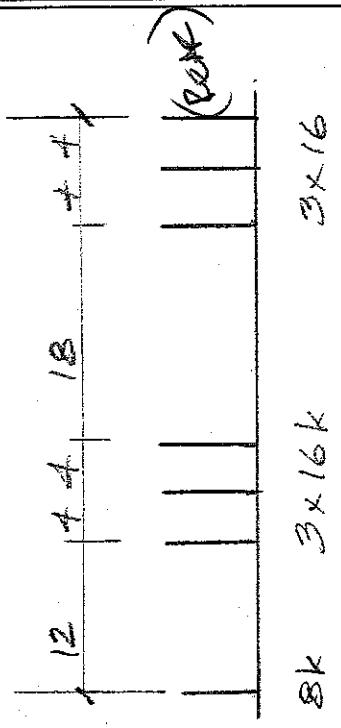


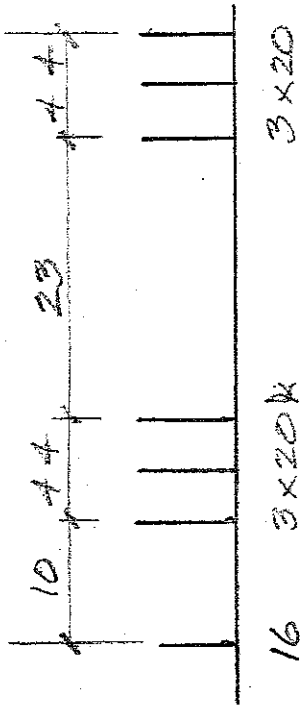
STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

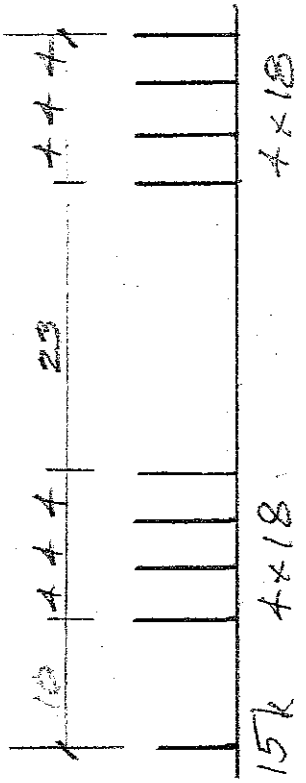
DESIGN COMPUTATIONS

SHEET NO. _____
BRIDGE NO. _____
MADE BY _____
CHKG. BY _____
DATE _____

DESIGN OF Std Permit Vehicles







Std A

104 k 46'
S_b Ft = .189 ksf

Std B

136 k 49'
S_b Ft = .233

Std C

159 k 57'
S_b Ft = .237

OVERWEIGHT PERMIT RESTRICTIONS for BRIDGES

Restriction Code	Restriction Description	Allowed		Detailed Restriction Description	Bridge Check Operation
		Single Trip Permit	Annual Permit		
1	None	YES	YES	No restrictions to drive over bridge.	Normal
2	Straddle two lanes	YES	YES	Drive on the centerline between two lanes, in a manner that prevents any other vehicle from occupying a part of either lane on either side of the permit vehicle. Drive in the center of a single lane bridge.	The AASHTO "Single Lane" live load distribution is used.
3	Maximum speed of **10** miles per hour	YES ①	YES ①	Drive at a speed of 10 miles per hour or less.	The impact factor is reduced from the AASHTO impact to **5 %**
4	Straddle two lanes at a maximum speed of **10** miles per hour	YES ①②	NO	Combine both restrictions 2 and 3 above; vehicle shall straddle two lanes at max. speed of 10 MPH.	Combine single lane distribution and reduce impact to **5 %**
5	Plank Bridge per MnDOT instructions	YES ②	NO	More specific instructions must be attached	Depends on the individual situation.
6	See specific MnDOT Instructions	YES ②	NO	More specific instructions must be attached	Depends on the individual situation.
7	Need MnDOT District Engineer approval	YES ②	NO	More specific instructions must be attached	Depends on the individual situation.
X	DENIED	YES	YES	This overweight permit vehicle is **NOT ALLOWED** on this bridge.	Used when requirements for restrictions 1 thru 7 are not met

① Not allowed where there is a posted minimum speed, such as most interstate mainline routes.

② Minimum escort: police at the front of permit vehicle.